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ABSTRACT

This curriculum guide contains the basic information needed to repair all two- and four-stroke cycle engines. The curriculum covers four areas, each consisting of one or more units of instruction that include performance objectives, suggested activities for teacher and students, information sheets, assignment sheets, job sheets, visual aids, criterion referenced tests, and test answers. Organization is as follows: (1) orientation: occupational introduction, safety, tools, and measuring; (2) basic small engine theory: engine identification and inspection, basic engine principles and design, principles of operation--four-stroke cycle, and principles of operation--two-stroke cycle; (3) electrical systems: basic electricity, ignition systems, charging systems, and starting systems; and (4) engine service: lubrication systems, cooling systems, fuel systems, governor systems, exhaust systems, troubleshooting, overhaul--four-stroke cycle engine, and overhaul--two-stroke cycle engine. (Several supplementary manuals are available to cover accompanying tasks for specific types of engines, e.g., motorcycles, snowmobiles, outboard motors). (BL)

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COMPREHENSIVE SMALL ENGINE REPAIR

by
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Developed by the
Mid-America Vocational Curriculum Consortium, Inc.

In cooperation with the
Instructional Materials Laboratory
University of Missouri - Columbia

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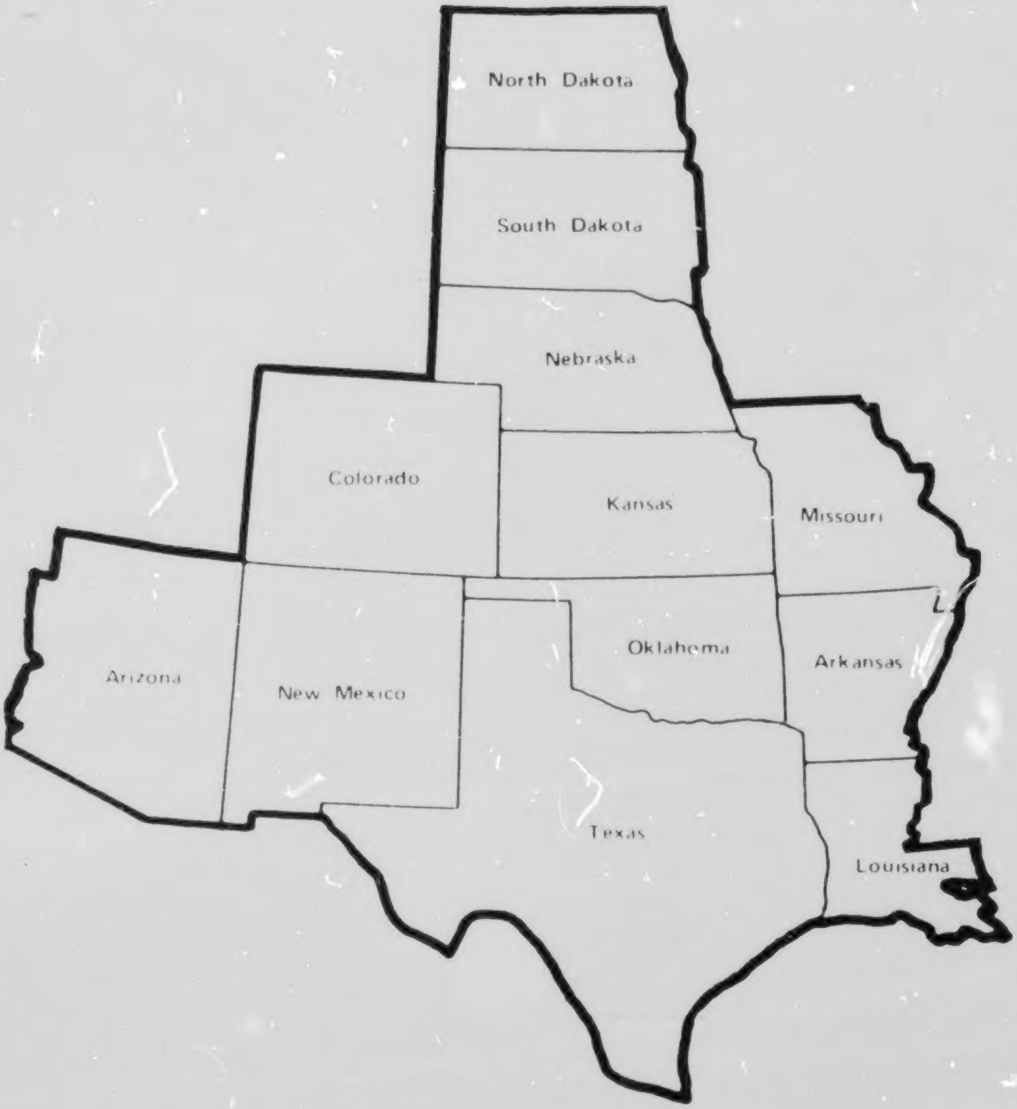
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PREFACE

For many years those responsible for teaching small engine repair have felt a need for instructional materials to use in this area. A team of teachers, industry representatives, and trade and industrial education staff members accepted this challenge and have produced manuals which will meet the needs of many types of courses where students are expected to become proficient in the area of small engine repair. The MAVCC *Comprehensive Small Engine Repair* publication is designed to include the basic information needed to be able to repair all two and four stroke cycle engines.

To insure that the student is able to perform the skills of a proficient small engine mechanic, five supplements have or are being prepared to accompany this publication. *Motorcycle Repair*, *Snowmobile Repair*, *Outboard Repair*, *Chainsaw Repair*, and *Lawn and Garden Equipment Repair* should assist the learner in acoomplishing the tasks of the small engine mechanic, even though they do not deal directly with the engine. Use of *Comprehensive Small Engine Repair* and any one of the supplements should lead toward the total repair of any one of these areas.

Every effort has been made to make this publication basic, readable and by all means usable. Three vital parts of instruction have been intentionally omitted from this publication: motivation, personalization, and localization. These areas are left to the individual instructors and the instructors should capitalize on them. Only then will this publication really become a vital part of the teaching-learning process.

Ann Benson
Executive Director
Mid-America Vocational
Curriculum Consortium, Inc.

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FOREWORD

The Mid-America Vocational Curriculum Consortium (MAVCC) was organized for the purpose of developing instructional material for the twelve member states. Priorites for developing MAVCC material are determined annually based on the needs as identified by all member states. One of the first priorities identified was comprehensive small engine repair. This publication is a part of a project designed to provide the needed instructional material for small engine repair programs.

The success of this publication is due, in large part, to the capabilities of the personnel who worked with its development. The technical writers have numerous years of industry as well as teaching experience. Assisting them in their efforts were representatives of each of the member states who brought with them technical expertise and the experience related to the classroom and to the trade. To assure that the materials would parallel the industry environment and be accepted as a transportable basic teaching tool, organizations and industry represenitves were involved in the developmental phases of the manual. Appreciation is extended to them for their valuable contributions to the manual.

This publication is designed to assist teachers in improving instruction. As these publications are used, it is hoped that the student performance will improve and that students will be better able to assume a role in their chosen occupation, small engine repair.

Instructional materials in this publication are written in terms of student performance using measurable objectives. This is an innovative approach to teaching that accents and augments the teaching/learning process. Criterion referenced evaluation instruments are provided for uniform measurement of student progress. In addition to evaluating recall information, teachers are encouraged to evaluate the other areas including process and product as indicated at the end of each instructional unit.

It is the sincere belief of the MAVCC personnel and all those members who served on the committees that this publication will allow the students to become better prepared and more effective members of the work force.

Don Eshelby, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

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Special thanks are extended to Amon Herd, Director, Instructional Materials Laboratory, University of Missouri-Columbia and his staff for their contributions toward the development of this book.

Gratitude is expressed to Regina Decker and Mary Kellum for editing and to the Graphics Division of the Oklahoma State Department of Vocational and Technical Education for typing.

Special appreciation goes to Dan Stapleton for the illustrations and drawings used in this publication.

The printing staff of the Oklahoma State Department of Vocational and Technical Education are deserving of much credit for printing this publication.

USE OF THIS PUBLICATION

Instructional Units

The *Comprehensive Small Engine Repair* curriculum includes four areas. Each area consists of one or more units of instruction. Each instructional unit includes some or all of the basic components of a unit of instruction: performance objectives, suggested activities for teacher and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the test. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help to determine:

A. The amount of material that can be covered in each class period.
B. The skills which must be demonstrated.
    1. Supplies needed
    2. Equipment needed
    3. Amount of practice needed
    4. Amount of class time needed for demonstrations
C. Supplementary materials such as pamphlets and filmstrips that must be ordered.
D. Resource people that must be contacted.

Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Following is a list of performance terms and their synonyms which may have been used in this material:

Name
Label
List in writing
List orally
Letter
Record
Repeat
Give

Identify
Select
Mark
Point out
Pick out
Choose
Locate

Describe
Define
Discuss in writing
Discuss orally
Interpret
Tell how
Tell what
Explain

Order
Arrange
Sequence
List in order
Classify
Divide
Isolate
Sort

Distinguish
Discriminate

Construct
Draw
Make
Build
Design
Formulate
Reproduce
Transcribe
Reduce
Increase
Figure

Demonstrate
Show your work
Show procedure
Perform an experiment
Perform the steps
Operate
Remove
Replace
Turn off/on
(Dis) assemble
(Dis) connect

Additional Terms Used
Evaluate
Complete
Analyze
Calculate
Estimate
Plan
Observe
Compare
Determine
Perform

Prepare
Make
Read
Tell
Teach
Converse
Lead
State
Write

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When teachers add objectives, they should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. The activities are listed according to whether they are the responsibility of the instructor or the student.

Instructor: Duties of the instructor will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Students: Student activities are listed which will help the student to achieve the objectives for the unit.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives of the unit. The teacher will find that information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skills specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to and in most situations should demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for students to follow if they have missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances which might reasonably be expected from a person who has had this training.

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledges which are necessary prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

COMPREHENSIVE SMALL ENGINE REPAIR

INSTRUCTIONAL ANALYSIS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

SECTION A--UNIT I: OCCUPATIONAL INTRODUCTION

1. Occupational outlook
2. Areas of employment
3. Career opportunities
4. Steps involved in shop work

UNIT II: SAFETY

1. Safety color code
2. Steps for maintaining a safe, orderly shop
3. Classes of fires
4. Types of fire extinguishers
5. Shop safety practices

UNIT III: TOOLS

1. Basic hand tools
2. Overhaul tools
3. Tool maintenance
4. Grind a flat tip screwdriver
5. Grind a chisel or punch head
6. Sharpen a chisel
7. Use thread repair kit
8. Check torque wrench
9. Replace a hammer handle

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT IV: MEASURING

	1. Measuring instruments
	2. Units of measurement
3. Use a vernier caliper	
4. Use a plain micrometer	
5. Use a dial indicator	

SECTION B--UNIT I: ENGINE IDENTIFICATION AND INSPECTION

	1. Two and four cycle engines
	2. Nameplates
	3. Operator's instructions
	4. Crankshaft positions

UNIT II: BASIC ENGINE PRINCIPLES AND DESIGN

	1. Energy
	2. Motion
	3. Simple machines
	4. Formulas for work, horsepower, and torque
	5. Heat engines
	6. Engine designs
	7. Engine cooling

UNIT III: PRINCIPLES OF OPERATION - FOUR-STROKE CYCLE

	1. Engine components
	2. Operation
	3. Multi-cylinder engines
	4. Camshafts
	5. Valve timing and overlap
	6. Valve arrangments

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT IV: PRINCIPLES OF OPERATION - TWO-STROKE CYCLE

1. Two-stroke cycle engine
2. Engine operation
3. Valves
4. Timing
5. Cross and loop scavenging
6. Two-stroke features
7. Exhaust system design

SECTION C--UNIT 1: BASIC ELECTRICITY

1. Sources
2. Basic circuits
3. Conductors
4. AC and DC current
5. Units of measure
6. Schematic symbols
7. Ohm's law
8. Series circuit rules
9. Parallel circuit rules
10. Magnetism
11. Induced voltage
12. Instruments
13. Problem solving

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT II: IGNITION SYSTEMS

1. Types
2. Purpose
3. Components - primary and secondary circuits
4. Magneto system
5. Solid state system
6. Breakerless system
7. Remove, service and replace spark plugs
8. Remove and replace contact points and condenser
9. Test the coil, condenser, armature and flywheel magnets
10. Test and adjust a solid state ignition system
11. Check ignition timing

UNIT III: CHARGING SYSTEMS

1. Kinds
2. Components
3. Operating stages
4. Current flow
5. AC-DC conversion
6. Generator regulators
7. Reverse polarity
8. Remove and replace a generator
9. Disassemble, check, and reassemble a generator
10. Remove and replace an alternator
11. Disassemble, check, and reassemble an alternator

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
UNIT IV: STARTING SYSTEMS	
	1. Types
	2. Components
	3. DC wound field starters
	4. Starter generators
	5. Starter drives
6. Remove, disassemble, test, service, and reassemble a starter	
7. Replace a starter rewind spring	
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	2. Types
	3. Engine oil
	4. Oil characteristics
5. Change engine oil and filter	
6. Service crankcase breather	
UNIT II: COOLING SYSTEMS	
	1. Functions
	2. Components
3. Remove, clean, and replace air cooling parts	
4. Pressure test the cooling system	
5. Remove, check, and replace a thermostat	
6. Remove and replace a water pump	
7. Remove and replace a radiator	
8. Remove, inspect and replace V-belts	
9. Test antifreeze solution	

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

UNIT III: FUEL SYSTEMS

	1. Purpose
	2. Types
	3. Components
	4. Fuel pumps
	5. Air cleaners
6. Service an air cleaner	
7. Remove and replace a carburetor	
8. Service a flank type carburetor	
9. Remove and replace a fuel pump	
10. Test and service a fuel pump	
11. Service sediment bowl fuel strainer	

UNIT IV: GOVERNOR SYSTEMS

	1. Purposes
	2. Types
	3. Components
4. Inspect, adjust, and repair an air vane governor	
5. Inspect and adjust external components of a mechanical governor with internal flyweights	
6. Repair internal components of a mechanical governor with internal flyweights	
7. Inspect, adjust, and repair a centrifugal governor with external governor unit	

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
UNIT V: EXHAUST SYSTEMS	
	1. Purposes
	2. Results of defective system
	3. Selection
	4. Dangers
5. Remove, service, and replace two cycle exhaust system components	
UNIT VI: TROUBLESHOOTING	
	1. Engine requirements
	2. Procedures
	3. Importance
4. Troubleshoot an engine	
UNIT VII: OVERHAUL FOUR-STROKE CYCLE ENGINE	
	1. Causes of engine problems
	2. Piston and connecting rods
	3. Crankshaft assembly
	4. Valve assembly
5. Disassemble a four stroke cycle engine	
6. Inspect and service a cylinder	
7. Inspect and service the piston, rings, and connecting rod	
8. Inspect and service crankshaft assembly	
9. Service multi-piece crankshaft assembly	
10. Reassemble a four-stroke cycle engine	

JOB TRAINING: What the
Worker Should Be Able to Do
(Psychomotor)

RELATED INFORMATION: What
the Worker Should Know
(Cognitive)

UNIT VIII: OVERHAUL TWO-STROKE CYCLE ENGINE

1. Causes of engine problems
2. Connecting rod and piston
3. Crankshafts
4. Disassemble, inspect, and service a two-stroke cycle engine
5. Service a multi-piece crankshaft
6. Reassemble a two-stroke cycle engine

TOOLS

(NOTE: These are the recommended tools and equipment necessary to complete the jobs required in these instructional materials.)

Hand Tool Assortment:
- Ball-peen hammer - one pound
- Slip joint pliers
- Screwdrivers
  - 4" standard
  - 1 1/2" standard
  - 8" standard
  - 6" standard
- Adjustable wrench
- Phillips screwdrivers
  - 6"
  - 1 1/2"
  - 8"
- 3/8" drive reversible ratchet
- 3/8" drive standard socket set
- 1/4" drive reversible ratchet
- 1/4" drive standard socket set
- 3/8" drive extension bar - 3 in.
- 3/8" drive extension bar - 7 1/2 in.
- Starter punch
- Cold chisel
- Combination wrench set 7/16 to 7/8 in.
- Universal joint
- Open end wrench set - metric
- 3/8 drive socket set - metric
- Safety glasses

Other Tools and Equipment:
- Combination wrench set - metric
- Vernier caliper
- Drain pan
- Hex key set
- Inside micrometer
- Outside micrometer
- Dial indicator
- End wrenches
- Impact screwdriver set
- Snap ring pliers
- T-handle box wrench, 16 mm
- Arbor press or bench vise
- Feeler gauge
- Flat surface plate
- Machinist's steel rule
- Calipers
- Surface block
- Case divider tool
- Impact driver
- Ring compressor
- 3/8" drive phillips screwdriver socket
- Soft face hammer
- Tape measure
- Cleaning pan
- Cleaning brush
- Grease pan
- Hot plate
- Thermomelt stick
- Plastic hammer
- Parts washing pan
- Pin wrench
- Propane torch
- Seal driver set
- Meter/kilogram torque wrench
- Soft drift
- Nipple wrench
- Bushing driver set
- Brass drift
- Pry bar
- Pliers
- Measuring container
- Cylinder gauge
- Shock absorber compressor
- Hydraulic press
- Drift punch
- V-blocks
- Surface plate
- DC voltmeter
- DC ammeter
- Test lamp
- Ohmmeter
- Spark plug wrench
- Ignition point gauge
- Tachometer
- Flywheel pullers
- Float level gauge
- 0-1" telescoping gauge
- Glutch head screwdriver set
- Battery clamp puller
- Battery hydrometer
- Battery post cleaner
- Funnel
- Thread repair kit
- Boring bar
- Piston ring expander
- Piston ring groove cleaner
- Drill motor
- Chisel set
- Ridge reamer

Ring groove gauge
Twist drill set
Valve grinder
Valve seat cutters
Valve spring compressor
Cylinder hone
Clutch wrench

REFERENCES

(NOTE: This is an alphabetized list of publications used in completing this manual.)

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OCCUPATIONAL INTRODUCTION
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list places of employment and discuss the occupational outlook for small gas engine mechanics. The student should also be able to list student requirements, name the steps involved in small gas engine shop work, and complete a personal information sheet. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Discuss the occupational outlook for small gas engine mechanics.
2. List three areas of employment for small gas engine mechanics.
3. Select places that employ small gas engine mechanics.
4. List careers open for students trained in small gas engines.
5. List seven student requirements for the small gas engine program.
6. Name seven steps involved in small gas engine shop work.
7. Complete personal information sheet.

OCCUPATIONAL INTRODUCTION
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

A. Provide student with objective sheet.

B. Provide student with information and assignment sheets.

C. Discuss unit and specific objectives.

D. Discuss information and assignment sheets.

(NOTE: Take up assignment sheet and file for reference purposes.)

E. Invite a small engine shop owner to talk with the students about career opportunities.

F. Take field trip to local small gas engine repair shop.

G. Give test.

II. Student:

A. Read objective sheet.

B. Study information sheet.

C. Complete assignment sheet.

D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

A. Objective sheet

B. Information sheet

C. Assignment Sheet #1--Complete Personal Information Sheet

D. Test

E. Answers to test

OCCUPATIONAL INTRODUCTION
UNIT I

INFORMATION SHEET

I. Occupational outlook

   A. Job opportunities result each year from the need to replace experienced mechanics who are promoted, retired, or transferred to related fields of work

   B. Number of small gas engine applications increases each year requiring more mechanics to service them

   C. Demand increases for qualified personnel to service new design and safety features

   (NOTE: These features include pollution control and noise prevention devices.)

II. Areas of employment

   A. Manufacturing

   B. Sales

   C. Service

III. Places of employment

   A. Independent repair shops for small engines

   B. Service departments of department stores

   C. Retail small engine stores

   D. Hardware stores with small shops

   E. Maintenance departments

   Example: Golf courses, cities, other government agencies

   F. Recreational vehicle franchises and independent dealerships

IV. Careers

   A Engine mechanic

   B. Service manager

   C. Sales manager

INFORMATION SHEET

   D. Owner/manager
   E. Technician
   F. Service representative
   G. Engineer
   H. Executive

V. Student requirements

   A. Understand and follow safety regulations
   B. Understand and operate shop equipment correctly
   C. Take instructions readily and follow directions
   D. Control temper
   E. Be enthusiastic about job
   F. Be on time
   G. Attend class

VI. Steps involved in shop work

   A. Diagnosis
   B. Disassembly
   C. Measuring
   D. Installation of parts
   E. Reassembly
   F. Adjustments
   G. Test

OCCUPATIONAL INTRODUCTION
UNIT I

ASSIGNMENT SHEET #1–COMPLETE PERSONAL INFORMATION SHEET

Fill in the appropriate data on the following personal information sheet.

Name: ____________________

Social Security Number: ____________________

Age: ____________________

Birth Date: ____________________

Grade: ____________________

Telephone Number: ____________________

Parent/Guardian Names: ____________________

Telephone Number for Emergencies: ____________________

Occupational Objective: ____________________

OCCUPATIONAL INTRODUCTION
UNIT I

TEST

1. Discuss the occupational outlook for small gas engine mechanics.

2. List the three areas of employment for small gas engine mechanics.

   a.

   b.

   c.

3. Select the places that employ small gas engine mechanics by placing an "X" in the appropriate blanks.

   _____a. Service departments of department stores

   _____b. Air-conditioning shops

   _____c. Banks

   _____d. Hardware stores with small shops

   _____e. Retail small engine stores

4. List six careers open for students trained in small gas engines.

   a.

   b.

   c.

   d.

   e.

   f.

5. List seven student requirements for the small gas engine program.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

6. Name seven steps involved in small gas engine shop work.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

7. Complete personal information sheet.

   (NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

OCCUPATIONAL INTRODUCTION
UNIT I

ANSWERS TO TEST

1. Discussion should include:
    - a. Job opportunities result each year from the need to replace experienced mechanics who are promoted, retired, or transferred to related fields of work
    - b. Number of small gas engine applications increases each year requiring more mechanics to service them
    - c. Demand increases for qualified personnel to service new design and safety features
2. a. Manufacturing
    - b. Sales
    - c. Service
3. a, d, e
4. Any six of the following:
    - a. Engine mechanic
    - b. Service manager
    - c. Sales manager
    - d. Owner/manager
    - e. Technician
    - f. Service representative
    - g. Engineer
    - h. Executive
5. a. Understand and follow safety regulations
    - b. Understand and operate shop equipment correctly
    - c. Take instructions readily and follow directions
    - d. Control temper

  e. Be enthusiastic about job
  f. Be on time
  g. Attend class

6. a. Diagnosis
  b. Disassembly
  c. Measuring
  d. Installation of parts
  e. Reassembly
  f. Adjustments
  g. Test

7. Evaluated to the satisfaction of the instructor

SAFETY
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to distinguish between safe and unsafe shop practices and list steps for maintaining a safe and orderly shop. The student should also be able to select the fire extinguishers for the classes of fires, match the colors of the safety color code to statements of their use, and complete the student safety pledge form. This knowledge will be evidenced through demonstration and by scoring eighty five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with safety to the correct definitions.
2. Match the colors of the safety color code to the correct statements of their use.
3. List steps for maintaining a safe and orderly shop.
4. Match the classes of fire to the correct statements defining each class.
5. Select the fire extinguishers best suited to extinguish each class of fire.
6. Distinguish between safe and unsafe shop practices.
7. List the four general shop safety rules.
8. Complete the student safety pledge form.
9. Complete the individual student shop safety inspection checklist.

SAFETY
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and assignment sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information and assignment sheets.

  F. Invite representative from fire department to talk about fire extinguisher use.

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete assignment sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1 Types of Fire Extinguishers

    2. TM 2 Use Care with Gasoline

    3. TM 3 Proper Use of Equipment

    4. TM 4 Unplug Equipment Before Working

    5. TM 5 Proper Handling of Batteries

D. Assignment Sheets

1. Assignment Sheet #1--Complete the Student Safety Pledge Form

2. Assignment Sheet #2--Complete the Individual Student Shop Safety Inspection Checklist

E. Test

F. Answers to test

II. References:

A. *The ABC's of Fire Protection.* Belleville, New Jersey: Kidde Portable Extinguishers/Walter Kidde and Co., Inc.

B. *An Accident Prevention Program for School Shops and Laboratories.* Washington, D.C.: Office of Education/U.S. Department of Health, Education, and Welfare.

C. *Federal Register. Vol. 36. Number 105. Part II.* Department of Education.

D. *Safety Practices and Procedures in School Shops.* Division of Vocational Education/New Jersey Department of Education.

E. *A Look at Service Safety.* Tecumseh, Michigan: Tecumseh Products Co.

SAFETY
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Safety--State or condition of being safe; freedom from danger, risk, or injury

B. Accident--Any suddenly occurring, unintentional event which causes injury or property damage

C. First-aid--Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

D. Carbon monoxide--Colorless, odorless, very poisonous gas formed by incomplete combustion

E. Battery--Number of complete electrical cells assembled in one housing or case; used in small engines to run and/or start the engine

F. Service manual--Professional book giving exact details, tools, and procedures for servicing one or more types of engines

G. Compressed oxygen--Oxygen processed for purity and compressed in bottles

Example: Oxygen bottle for oxyacetylene welding

H. Carburetor and/or parts cleaner--Chemical solution for dissolving deposits such as grease, varnish, gum, and paint from parts without damage to the metal

I. OSHA--Occupational Safety and Health Act

II. Colors and applications of the safety color code

A. Green--Designates location of safety and first aid equipment

(NOTE: This is applied to noncritical parts of equipment and machined surfaces, nameplates, and bearing surfaces.)

B. Yellow--Designates caution

(NOTE: This is applied to operating levers, wheels, handles, and hazardous areas which may cause stumbling, falling or tripping.)

INFORMATION SHEET

C. Orange–Designates dangerous parts of equipment which may cut, crush, shock, or otherwise injure

(NOTE: This is applied to electrical switches, interior surfaces of doors, on fuse and electrical power boxes, movable guards, and parts.)

D. Red–Identifies the location of fire fighting equipment

(NOTE: Emergency fire exits shall be designated in red. Gasoline cans should be painted red with additional identification in the form of a yellow band around the can. Buttons or levers for electrical switches, used for stopping of machinery, should also be designated in red.)

E. Blue–Designates caution against starting equipment while it is being worked on, or against the use of defective equipment

(NOTE: Blue tag should be lettered "Out of Order.")

F. Ivory–Reflects light and "shows the way"

(NOTE: This is applied to label edges, vise jaws, and edges of tool rests.)

III. Steps for maintaining a safe and orderly shop

A. Arrange machinery and equipment to permit safe, efficient work practices and ease in cleaning

B. Stack or store materials and supplies safely in proper places

C. Store tools and accessories safely in cabinets, racks, or other suitable devices

D. Keep working areas and work benches clear and free of debris and other hazards

E. Keep floors clean and free from obstructions and slippery substances

F. Keep aisles, traffic areas, and exits free of material and other debris

G. Properly dispose of combustible materials or store them in approved containers

H. Store oily rags in self-closing or spring lid metal containers

I. Know the proper procedures to follow in keeping the work area clean and orderly

INFORMATION SHEET

J. Have sufficient brooms, brushes, or other housekeeping equipment readily available

IV. Classes of fires

A. Class A--Fires that occur in ordinary combustible materials such as wood, rags, and rubbish

B. Class B--Fires that occur with flammable liquids such as gasoline, oil, grease, paint, and thinners

C. Class C--Fires that occur in or near electrical equipment such as motors, switchboards, and electrical wiring

D. Class D--Fires that occur with combustible metals such as magnesium

V. Fire extinguishers used on the classes of fires (Transparency 1)

A. Pressurized water--Class A fires

(NOTE: This is operated by squeezing the handle or trigger.)

B. Soda acid--Class A fires

(NOTE: This is operated by turning the extinguisher upside down.)

C. Carbon dioxide (CO_2)--Class B and C fires

(NOTE: This is operated by squeezing the handle or trigger.)

D. Dry chemical--Class B, C, and D fires

(NOTE: This is operated by squeezing the handle or trigger.)

E. Foam--Class A and B fires

(NOTE: This is operated by turning the extinguisher upside down.)

F. Fire blanket--All classes of fires

(NOTE: Fire blankets are normally used for outside fires or for those small enough to be contained by the blanket.)

VI. Rules of safety

A. Fire prevention (Transparency 2)

1. Never strike sparks in a room or area where flammable liquids are used or stored

INFORMATION SHEET

2. Use only approved safety cans for storage of flammable liquids and label them properly

3. Do not fill a hot or running engine with gasoline

   (NOTE: It may spill and cause a fire.)

4. Use a commercial nonflammable cleaner for cleaning tools and parts

   (NOTE: Do not use gasoline as a cleaner for tools or parts.)

5. Change any oil or gasoline soaked clothes immediately

   (NOTE: A spark, a hot exhaust manifold, or an open flame can easily ignite such clothing.)

6. Learn the location and use of fire extinguishers for each class of fire

7. Dispose of oil or gasoline soaked rags and other debris in self-closing, air-tight metal containers provided for this purpose

8. Avoid placing live electrical wires near fuel lines, carburetors, gas tanks, or fuel storage containers

B. Oil and grease

1. Wipe up at once any spilled oil, grease, or other liquids

   (NOTE: Use oil absorbent materials on the oil; this will prevent slipping.)

2. Do not direct oil spray toward other workers

3. Always have the proper container at hand to catch fuel, oil, or other fluids before attempting to drain them

   (NOTE: When the fluid has been drained, move it to a safe place away from fire hazards.)

4. Do not pour old oil on the ground, down a drain, or into a natural watershed

   (NOTE: Consult your instructor regarding local ordinances for disposal of oil and grease.)

5. Do not oil an engine while it is running or attempt to oil or wipe moving parts

INFORMATION SHEET

C. Eye protection--Always use safety goggles while performing the following operations or as required by state and school laws or policy

1. Grinding, chipping, or drilling
2. Working under equipment
3. Operating abrasive discs
4. Charging batteries or using caustic cleaning compounds

   (NOTE: Wear splash proof goggles when using acids or caustic liquids such as carburetor and parts cleaners.)

D. Electrical

1. Any and all dangerous conditions of equipment should be reported to the instructor
2. Treat all electrical equipment as "live" until you have carefully checked
3. Use third wire cords and plugs to ground all portable lights and tools

   (NOTE: This is not necessary on tools that are double insulated.)

4. Check the condition of cords, plugs, and sockets
5. Eliminate cords and wires as trip hazards
6. Coil and hang or store power tools and cords properly
7. Be prepared to turn off any electrical power switch and/or main switch in case of emergency

E. Air pressure

1. Never use compressed air equipment for dusting off clothing or work benches

   (NOTE: Flying particles may be blown into the eyes or skin of yourself or others.)

2. Never use compressed oxygen in place of compressed air
3. Use compressed air only for the purpose for which it is intended and in a manner approved by OSHA

INFORMATION SHEET

F. Equipment (Transparencies 3 and 4)

1. Do not operate any machine without having been instructed in its use

2. Never start an engine before determining that everyone is in the clear

3. Never start an engine without knowing how to shut it off and being ready to do so if the need calls for it

4. Keep hands and clothing away from moving parts

   (NOTE: A few of the moving parts that concern us are flywheels, blades, fans, gears, pulleys, belts, chains, generators, and power take off (PTO) shafts.)

5. Never run an engine in an inadequately ventilated place

   (NOTE: Remember that carbon monoxide fumes from an engine can kill.)

6. Read and heed all notes and cautions

   (NOTE: Throughout this material and in almost every service manual you will come across many passages with these headings.)

7. Read instructions thoroughly and follow them carefully

   (NOTE: Do not attempt shortcuts.)

8. If you lack the proper tools or have doubts of your ability to do the job correctly, consult your instructor

9. Light your work area adequately

   (NOTE: Have a portable safety light for working under equipment.)

10. Wear reasonably tight fitting, appropriate clothing while working in the shop

11. Never wear a necktie, necklace, or other loose apparel to work in the shop

    (NOTE: Button sleeves and secure or cover long hair behind your head or up to prevent snagging in power equipment.)

INFORMATION SHEET

12. Always disconnect and ground the wire from the spark plug before inspecting or repairing any mower, tiller, saw, or other power equipment

    (NOTE: The engine may accidentally start and cause serious injury.)

13. After reassembly be sure all parts, nuts, bolts, and screws are securely in place

    (NOTE: Loose or missing parts can interfere with the operation of the equipment and damage or injury may result.)

G. Batteries (Transparency 5)

1. Handle batteries with care and use a battery strap or carrier
2. Always hold battery upright and set securely so there is no danger of spilling acid
3. Never smoke, use an open flame, or cause a spark on battery terminals especially on a charging battery or charging area

   (NOTE: Hydrogen gas is given off in charging and it may explode and spatter acid.)

4. Wear protective clothing such as chemical goggles, rubber aprons, gloves, and boots while working in battery charging operations
5. When mixing battery solutions, always pour acid into water

   (NOTE: Reversing this mixing procedure to water into acid increases the possibility of splashing the acid on you.)

6. If acid splashes on you, flush immediately with plenty of cold water and notify instructor

   (NOTE: This is especially important if acid gets in your eyes.)

7. Do not short circuit the battery to test it

   (NOTE: A fire or explosion may result.)

8. Prevent accidential short circuits by disconnecting and insulating grounded battery cable before working on equipment

INFORMATION SHEET

VII. General shop safety rules

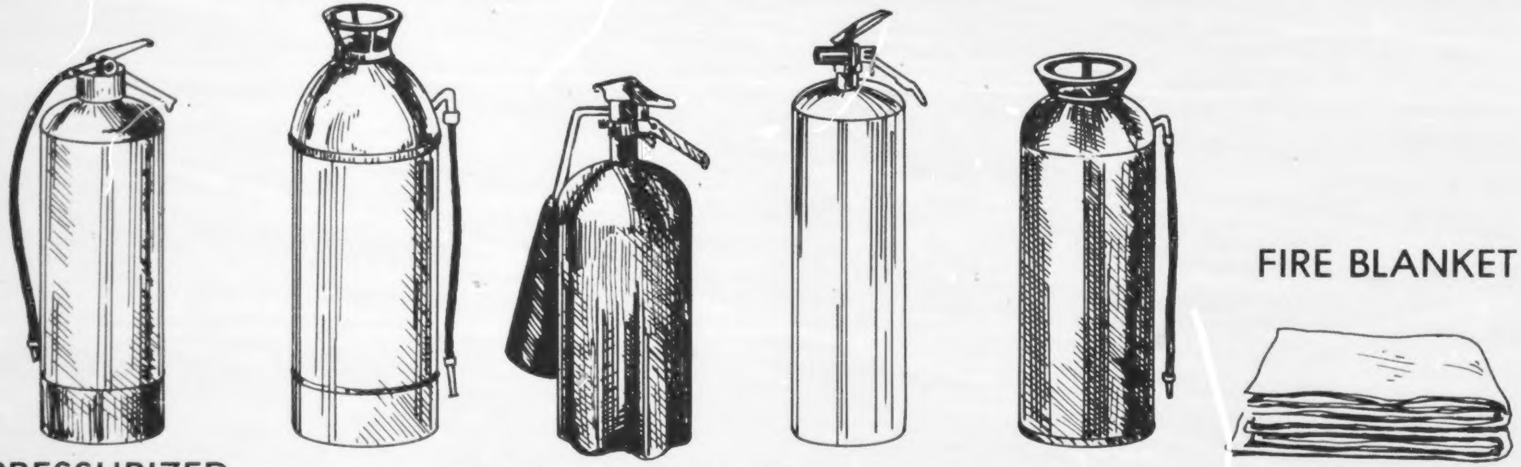
A. All injuries should be treated at once

B. Safety equipment and shoes should be used and worn as required

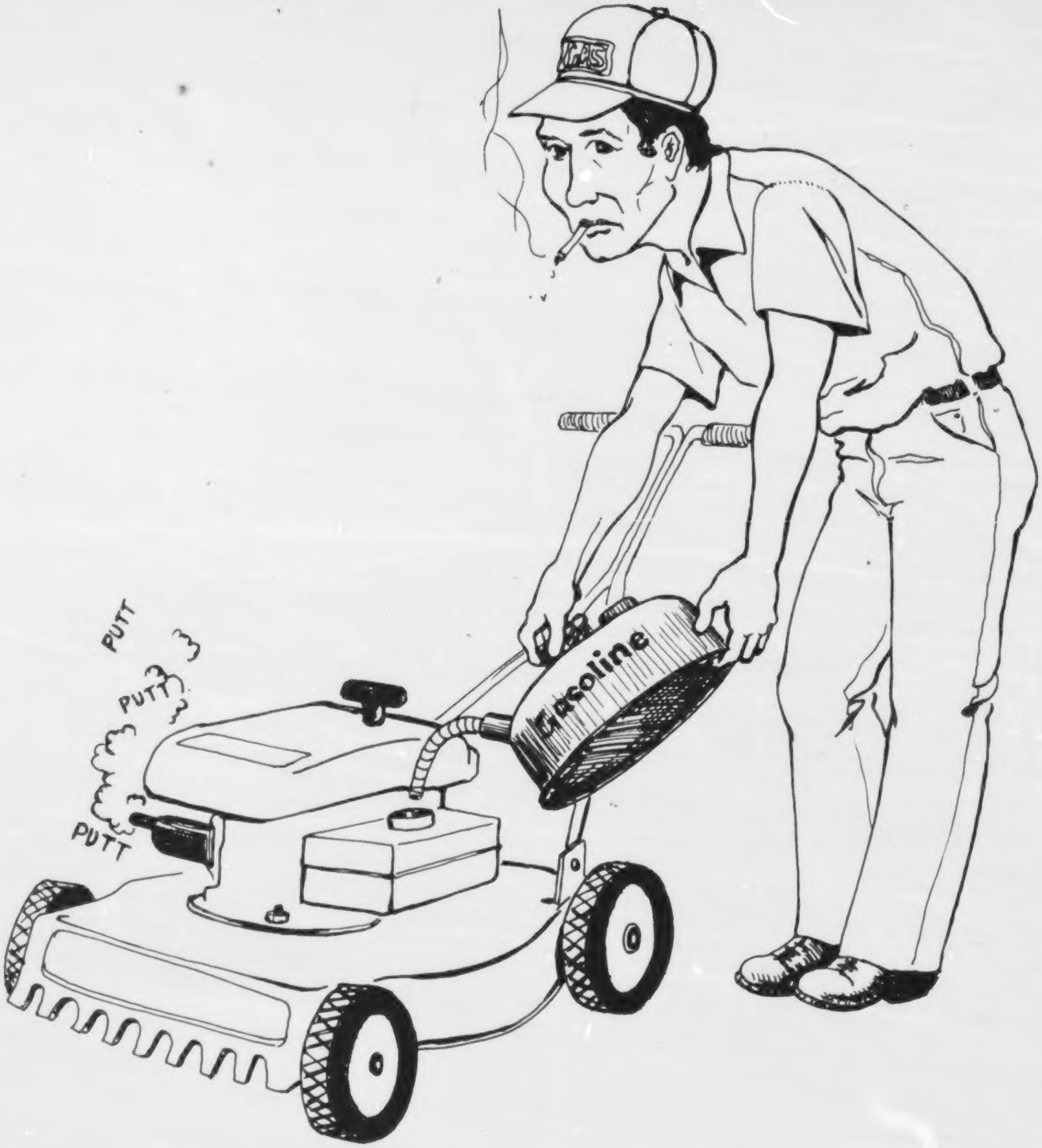
C. Running and horseplay are not permitted in the shop at any time

D. Any and all dangerous conditions or damaged equipment should be reported to the instructor

TYPES OF FIRE EXTINGUISHERS


SODA-ACID
DRY CHEMICAL
FIRE BLANKET
PRESSURIZED WATER
CARBON DIOXIDE
FOAM

USE CARE WITH GASOLINE



PUTT
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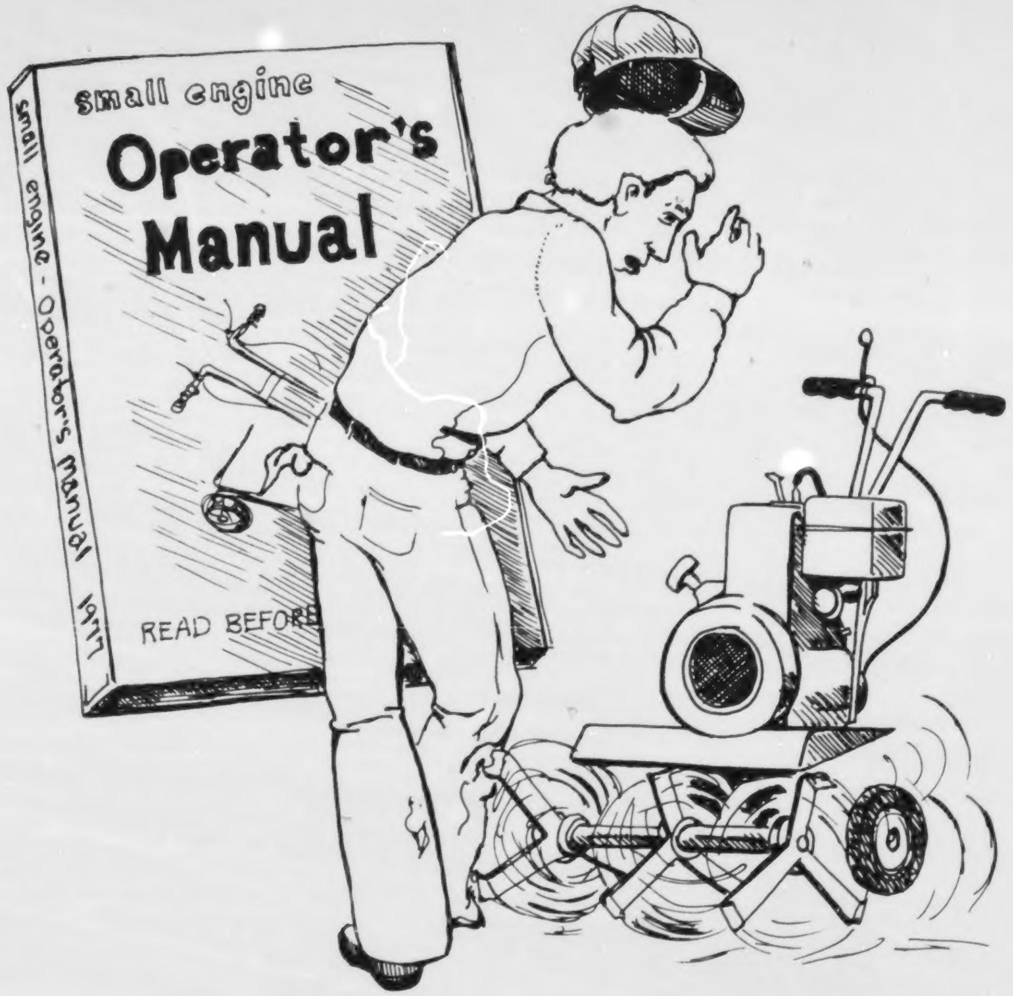
Gasoline

PROPER USE OF EQUIPMENT

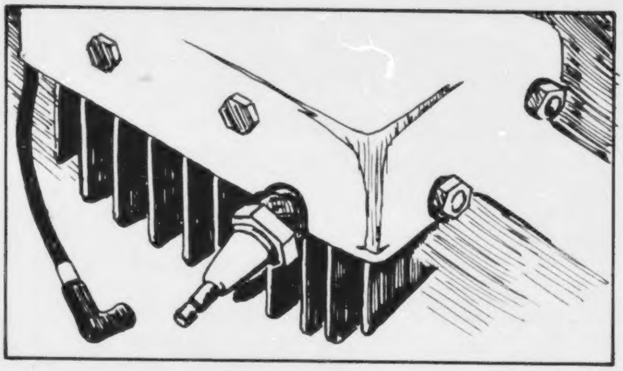

small engine
Operator's
Manual
small engine - Operator's manual 1977
READ BEFORE

READ YOUR OPERATOR'S MANUAL BEFORE
OPERATING EQUIPMENT

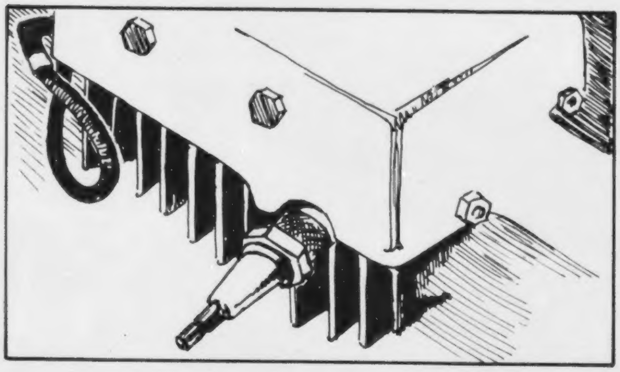
DO NOT WEAR LOOSE FITTING CLOTHING
AROUND EQUIPMENT, AND STAY CLEAR OF THE MOVING
PARTS WHILE THE ENGINE IS RUNNING

UNPLUG EQUIPMENT BEFORE WORKING

wrong



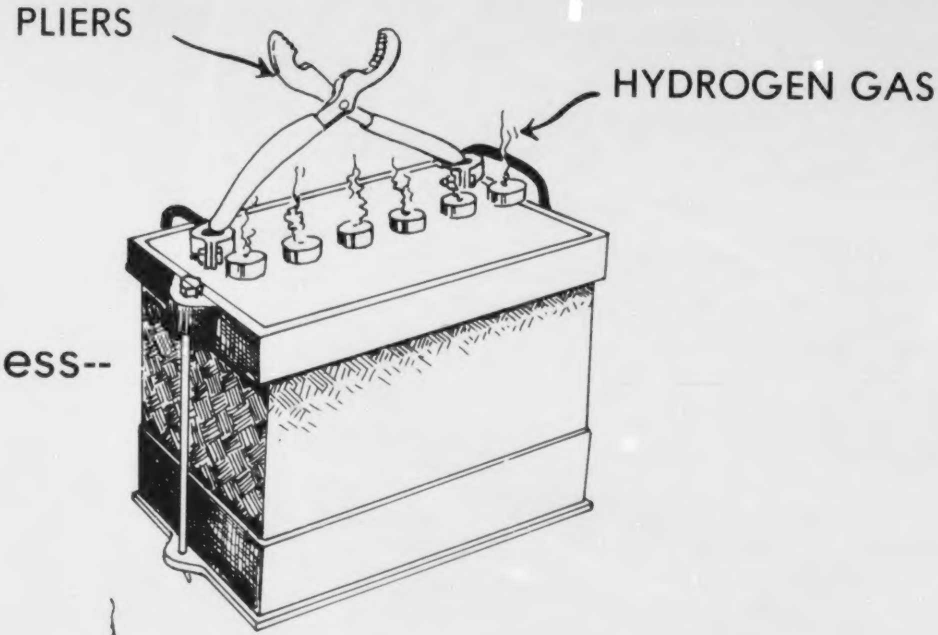
right



DISCONNECT THE SPARK PLUG LEAD
TO KEEP THE ENGINE FROM
ACCIDENTLY STARTING

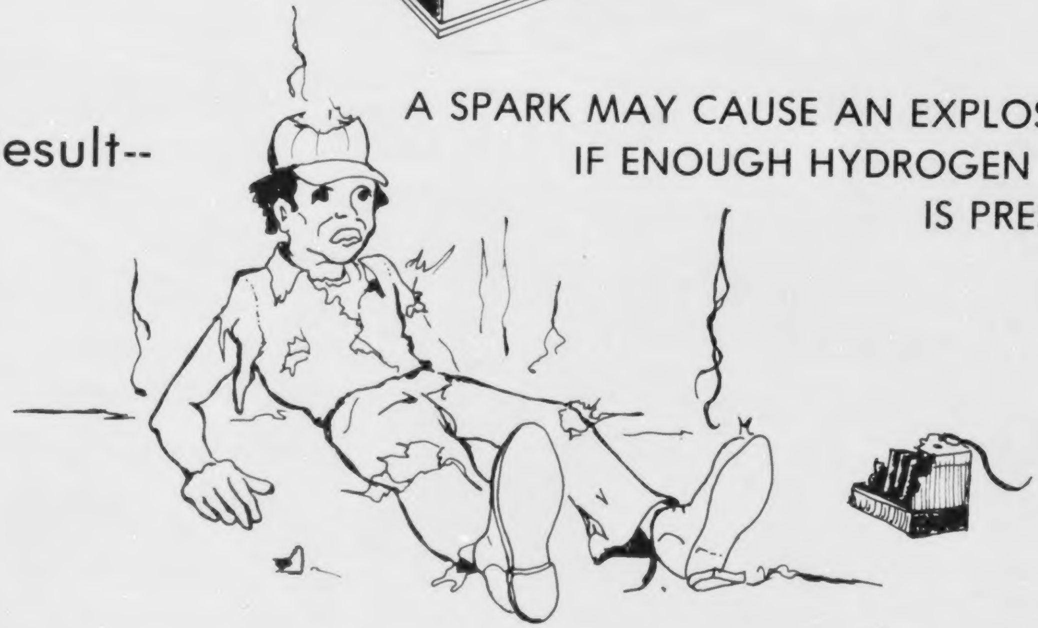
PROPER HANDLING OF BATTERIES

DO NOT ARC TERMINALS TO TEST - OR TO CAUSE A SPARK


PLIERS
HYDROGEN GAS

Carelessness--

Result--



A SPARK MAY CAUSE AN EXPLOSION
IF ENOUGH HYDROGEN GAS
IS PRESENT

SAFETY
UNIT II

ASSIGNMENT SHEET #1-COMPLETE STUDENT SAFETY PLEDGE FORM

Read and complete the student safety pledge form by filling in the blanks.

STUDENT SAFETY PLEDGE FORM

__________ __________ __________, who is enrolled in Vocational __________ __________, will as a part of the shop experience, operate machines, providing that the parent or guardian gives written permission.

It is understood that each student will be given proper instruction, both in the use of the equipment and correct safety procedures concerning it, before being allowed to operate the machines. The student must assume responsibility for following safe practices; therefore, we ask that the student subscribe to the following safety pledge.

1. I PROMISE TO FOLLOW ALL SAFETY RULES FOR THE SHOP.
2. I PROMISE NEVER TO USE A MACHINE WITHOUT FIRST HAVING PERMISSION FROM THE INSTRUCTOR.
3. I WILL NOT ASK PERMISSION TO USE A PARTICULAR MACHINE UNLESS I HAVE BEEN INSTRUCTED IN ITS USE, AND HAVE MADE 100% ON THE SAFETY TEST FOR THAT MACHINE.
4. I WILL REPORT ANY ACCIDENT OR INJURY TO THE TEACHER IMMEDIATELY.

DATE __________ STUDENT'S SIGNATURE ____________________

I hereby give my consent to allow my son or daughter to operate all machines and equipment necessary in carrying out the requirements of the course in which he/she is enrolled.

DATE __________ PARENT'S SIGNATURE ____________________
(If required)

Parents are cordially invited to visit the shop to inspect the machines and to see them in operation.

SAFETY
UNIT II

ASSIGNMENT SHEET #2--COMPLETE INDIVIDUAL STUDENT SHOP SAFETY INSPECTION CHECKLIST

Complete the safety inspection checklist by physically conducting an inspection of the shop area.

CHECKING PROCEDURE

Draw a circle around the appropriate letter, using the following letter scheme:

S -- Satisfactory (needs no attention)
A -- Acceptable (needs some attention)
U -- Unsatisfactory (needs immediate attention)

Recommendations should be made in all cases where a "U" is circled. Space is provided at the end of the form for such comments.

A. GENERAL PHYSICAL CONDITION

1. Machines, benches, and other equipment are arranged to conform to good safety practices S A U
2. Condition of stairways and ramps S A U
3. Condition of aisles S A U
4. Condition of floors S A U
5. Condition of walls, windows, and ceiling S A U
6. Illumination is safe, sufficient, and well placed S A U
7. Ventilation is adequate and proper for conditions S A U
8. Temperature control S A U
9. Fire extinguishers are of proper type, adequately supplied, properly located, and maintained S A U
10. Teacher and students know location of and how to use proper type for various fires S A U
11. Number and location of exits is adequate and properly identified S A U

ASSIGNMENT SHEET #2

12. Walls are clear of objects that might fall S A U

13. Utility lines are properly identified S A U

14. Air in shop is free from excessive dust and smoke S A U

15. Evaluation for the total rating of GENERAL PHYSICAL CONDITION S A U

B. HOUSEKEEPING

1. General appearance of orderliness S A U

2. Adequate and proper storage space for tools and materials S A U

3. Benches are kept orderly S A U

4. Corners are clean and clear S A U

5. Special tool racks, in orderly condition, and provided at benches and machines S A U

6. Tool, supply, and/or material room is orderly S A U

7. Sufficient scrap boxes are provided S A U

8. Scrap stock is put in scrap boxes promptly S A U

9. Materials are stored in an orderly and safe condition S A U

10. A spring lid metal container is provided for waste and oily rags S A U

11. Dangerous materials are stored in metal cabinets S A U

12. Machines have been color conditioned S A U

13. Safety cans are provided for flammable liquids S A U

14. Floors are free of oil, water, and foreign material S A U

15. Evaluation for the total rating for HOUSEKEEPING S A U

ASSIGNMENT SHEET #2

C. EQUIPMENT

1. Machines are arranged so that workers are protected from hazards of other machines and passing students S A U
2. Danger zones are properly indicated and guarded S A U
3. All gears and moving belts are protected by permanent enclosure guards S A U
4. All equipment control switches are easily available to operator S A U
5. Nonskid areas are provided around machines S A U
6. Tools are kept sharp, clean, and in safe working order S A U
7. Evaluation for the total rating for EQUIPMENT S A U

D. ELECTRICAL INSTALLATION

1. All switches are enclosed S A U
2. There is a master control switch for all electrical installations S A U
3. All electrical extension cords are in safe condition and are not carrying excessive loads S A U
4. All machine switches are within easy reach of the operators S A U
5. Individual cut-off switches are provided for each machine S A U
6. No temporary wiring S A U
7. Evaluation for the total rating for ELECTRICAL INSTALLATION S A U

ASSIGNMENT SHEET #2

E. PERSONAL PROTECTION (Read only)

1. Goggles or protective shields are provided and required for all work where eye hazards exist
2. If individual goggles are not provided, hoods and goggles are properly disinfected before use
3. Shields and goggles are provided for welding
4. Rings and other jewelry are removed by students when working in the shop
5. Proper kind of wearing apparel is worn and worn properly for the job being done
6. Leggings and safety shoes are worn in special classes
7. Respirators are provided for dusty or toxic atmospheric conditions such as when spraying occurs in the finishing room
8. Provisions are made for cleaning and sterilizing respirators
9. Students are examined for safety knowledge
10. Sleeves are rolled above elbows when operating machines
11. Clothing of students is free from loose sleeves, flopping ties, and loose coats

RECOMMENDATIONS

SAFETY
UNIT II

NAME ______________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. State or condition of being safe; freedom from danger, risk, or injury

_____b. Any suddenly occurring, unintentional event which causes injury or property damage

_____c. Occupational Safety and Health Act

_____d. Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

_____e. Chemical solution for dissolving deposits such as grease, varnish, gum and paint from parts without damage to the metal

_____f. Professional book giving exact details, tools, and procedures for servicing one or more types of engines

_____g. Oxygen processed for purity and compressed in bottles

_____h. Number of complete electrical cells assembled in one housing or case; used in small engines to run and/or start the engine

_____i. Colorless, odorless, very poisonous gas formed by incomplete combustion

1. OSHA
2. Battery
3. Safety
4. Accident
5. First aid
6. Carbon monoxide
7. Service manual
8. Compressed oxygen
9. Carburetor and/or parts cleaner

2. Match the colors of the safety color code on the right to the correct statements of their use.

_____a. Designates caution

_____b. Identifies the location of fire fighting equipment

_____c. Designates location of safety and first aid equipment

_____d. Designates dangerous parts of equipment which may cut, crush, shock, or otherwise injure

_____e. Designates caution against starting equipment while it is being worked on, or against the use of defective equipment

_____f. Reflects light and "shows the way"

1. Green
2. Ivory
3. Orange
4. Yellow
5. Blue
6. Red

3. List five steps for maintaining a safe and orderly shop.

a.

b.

c.

d.

e.

4. Match the classes of fire on the right to the correct statements defining each class.

_____a. Fires that occur with flammable liquids such as gasoline, oil, grease, paint, and thinners

_____b. Fires that occur in ordinary combustible materials such as wood, rags, and rubbish

_____c. Fires that occur with combustible metals such as magnesium

_____d. Fires that occur in or near electrical equipment such as motors, switchboards, and electrical wiring

1. Class A
2. Class B
3. Class C
4. Class D

5. Select the fire extinguisher best suited to extinguish each class of fire by placing an "X" in the appropriate blanks under each section.

a. Class A

______1) Soda acid

______2) Dry chemical

______3) Pressurized water

______4) Foam

______5) Fire blanket

b. Class B

______1) Pressurized water

______2) Carbon dioxide (CO_2)

______3) Dry chemical

______4) Foam

______5) Fire blanket

c. Class C

______1) Foam

______2) Dry chemical

______3) Soda acid

______4) Carbon dioxide (CO_2)

______5) Fire blanket

d. Class D

______1) Foam

______2) Dry chemical

______3) Soda acid

______4) Carbon dioxide (CO_2)

______5) Fire blanket

6. Distinguish between safe and unsafe shop practices by placing an "S" in the appropriate blanks if the practice is safe and a "U" if it is unsafe.

a. Fire Prevention

______1) Never strike sparks in a room or area where flammable liquids are used or stored

______2) Use only approved safety cans for storage of flammable liquids and label them properly

______3) Gasoline may be poured into an engine at any time

______4) Wash engine parts in a pan of gasoline

______5) Change any oil or gasoline soaked clothes immediately

______6) Learn the location and use of fire extinguishers for each class of fire

______7) Dispose of oily rags by throwing them in a corner or under a table out of the way

______8) Avoid placing live electrical wires near fuel lines, carburetors, gas tanks, or fuel storage containers

b. Oil and Grease

______1) When a job is messy and more oil will be spilled on the floor, wait until the job is completed to use oil absorbent materials to clean the floor

______2) Do not direct oil spray toward other workers

______3) Always have the proper container at hand to catch fuel, oil, or other fluids before attempting to drain them

______4) Pour old oil down the drain

______5) The best time to do a good oil job is when the machine or engine is running

c. Eye Protection--Always use safety goggles while performing the following operations or as required by state and school laws or policy:

______1) Grinding, chipping, or drilling

______2) Working under equipment

______3) Operating abrasive discs

______4) Charging batteries or using caustic cleaning compounds

d. Electrical

______1) Any and all dangerous conditions of equipment should be reported to the instructor

______2) Treat all electrical equipment as "live" until you have carefully checked

______3) Use two wire cords and plugs to ground for all portable lights and tools

______4) Check the condition of cords, plugs, and sockets

______5) Eliminate cords and wires as trip hazards

______6) Leave out tools and pieces of equipment where you finish work today so you can quickly resume work tomorrow

______7) Be prepared to turn off any electrical power switch and/or main switch in case of emergency

e. Air Pressure

______1) Use compressed air equipment for dusting off clothing and work benches

______2) Never use compressed oxygen in place of compressed air

______3) Use compressed air only for the purpose for which it is intended and in a manner approved by OSHA

f. Equipment

______1) Do not operate any machine without having been instructed in its use

______2) Start an engine when you are ready and hope that everyone is in the clear

______3) Never start an engine without knowing how to shut it off and being ready to do so if the needs calls for it

______4) Keep hands and clothing away from moving parts

______5) Never run an engine in an inadequately ventilated place

______6) Read and heed all notes and cautions

______7) Read instructions thoroughly and follow them carefully

______8) If you lack the proper tools or have doubts of your ability to do the job correctly, consult your instructor

______9) Light your work area adequately

_____10) Wear reasonably tight fitting shorts or cutoffs while working in the shop

_____11) Wear a necktie and loose fitting apparel to work in the shop

_____12) Always disconnect and ground the wire from the spark plug before inspecting or repairing any mower, tiller, saw, or other equipment

_____13) After reassembly be sure all parts, nuts, bolts, and screws are securely in place

g. Batteries

_____1) Handle batteries with care and use a battery strap or carrier

_____2) Always hold battery upright and set securely so there is no danger of spilling acid

_____3) Disconnect the battery charger from the terminals before shutting off the machine, even though it may spark

_____4) Wear protective clothing such as chemical goggles, rubber aprons, gloves, and boots while working in battery charging operations

_____5) If acid splashes on you, flush immediately with plenty of water and notify instructor

_____6) When mixing battery solutions, always pour water into acid

_____7) Test a battery with a pair of pliers, between the terminals, if it is believed to be dead

_____8) Prevent accidental short circuits by disconnecting and insulating grounded battery cable before working on equipment

7. List the four general shop safety rules.

a.

b.

c.

d.

8. Complete the student safety pledge form.

9. Complete the individual student shop safety inspection checklist.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

SAFETY
UNIT II

ANSWERS TO TEST

1. a. 3
   b. 4
   c. 1
   d. 5
   e. 9
   f. 7
   g. 8
   h. 2
   i. 6

2. a. 4
   b. 6
   c. 1
   d. 3
   e. 5
   f. 2

3. Any five of the following:
   a. Arrange machinery and equipment to permit safe, efficient work practices and ease in cleaning
   b. Stack or store materials and supplies safely in proper places
   c. Store tools and accessories safely in cabinets, racks, or other suitable devices
   d. Keep working areas and work benches clear and free of debris and other hazards
   e. Keep floors clean and free from obstructions and slippery substances
   f. Keep aisles, traffic areas, and exits free of materials and other debris
   g. Properly dispose of combustible materials or store them in approved containers
   h. Store oily rags in self-closing or spring-lid metal containers
   i. Know the proper procedures to follow in keeping the work area clean and orderly
   j. Have sufficient brooms, brushes, or other housekeeping equipment readily available

4. a. 2
   b. 1
   c. 4
   d. 3

5. a. 1, 3, 4, and 5
   b. 2, 3, 4, and 5
   c. 2, 4, and 5
   d. 2 and 5

6. a. 1) S
      2) S
      3) U
      4) U
      5) S
      6) S
      7) U
      8) S
   b. 1) U
      2) S
      3) S
      4) U
      5) U
   c. 1) S
      2) S
      3) S
      4) S
   d. 1) S
      2) S
      3) U
      4) S
      5) S
      6) U
      7) S
   e. 1) U
      2) S
      3) S

f.
1) S
2) U
3) S
4) S
5) S
6) S
7) S
8) S
9) S
10) U
11) U
12) S
13) S

g.
1) S
2) S
3) U
4) S
5) S
6) U
7) U
8) S

7. a. All injuries should be treated at once

b. Safety equipment and shoes should be used and worn as required

c. Running and horseplay are not permitted in the shop at any time

d. Any and all dangerous conditions or damaged equipment should be reported to the instructor

8. Evaluated to the satisfaction of the instructor

9. Evaluated to the satisfaction of the instructor

TOOLS
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify tools and demonstrate maintenance procedures for these tools. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with tools to the correct definitions.
2. Identify the basic hand tools needed for maintenance and repair of small engines.
3. Identify the tools used for overhaul of small engines.
4. Identify the types of torque wrenches.
5. Discuss maintenance procedures for tools.
6. Demonstrate the ability to:
    a. Grind a flat tip screwdriver.
    b. Grind the head of chisel or punch.
    c. Sharpen a chisel.
    d. Repair damaged threads using a thread repair kit.
    e. Check torque wrench for accuracy.
    f. Replace a hammer handle.

TOOLS
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:
  - A. Provide student with objective sheet.
  - B. Provide student with information and job sheets.
  - C. Make transparencies.
  - D. Discuss unit and specific objectives.
  - E. Discuss information and job sheets.
  - F. Demonstrate and discuss the procedures outlined in the job sheets.
  - G. Show examples of tools.
  - H. Make available the manuals and other visuals which discuss the use and care of tools.
  - I. Give test.

II. Student:
  - A. Read objective sheet.
  - B. Study information sheet.
  - C. Complete job sheets.
  - D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:
  - A. Objective sheet
  - B. Information sheet
  - C. Transparency masters
    - 1. TM 1--Basic Hand Tools
    - 2. TM 2--Basic Hand Tools (Continued)
    - 3. TM 3--Basic Hand Tools (Continued)
    - 4. TM 4--Basic Hand Tools (Continued)

5. TM 5--Basic Hand Tools (Continued)
6. TM 6--Overhaul Tools
7. TM 7--Overhaul Tools (Continued)
8. TM 8--Overhaul Tools (Continued)
9. TM 9--Overhaul Tools (Continued)
10. TM 10--Torque Wrenches

F. Job sheets

1. Job Sheet #1--Grind a Flat Tip Screwdriver
2. Job Sheet #2--Grind the Head of Chisel or Punch
3. Job Sheet #3--Sharpen a Chisel
4. Job Sheet #4--Repair Damaged Threads Using a Thread Repair Kit
5. Job Sheet #5--Check Torque Wrench for Accuracy
6. Job Sheet #6--Replace a Hammer Handle

G. Test

H. Answers to test

II. References:

A. American Association for Vocational Instructional Materials. *Small Engines Volume 1 and 2.* Athens, Georgia: AAVIM, 1974.

B. Bear, W. Forrest and Thomas A. Hoerner. *Torque and Torque Wrenches.* St. Paul, Minnesota: Hobar Publications, 1971.

TOOLS
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Hand tool--Tool which is hand held and is not electrical or specialized

      (NOTE: The majority of the repair work done in this trade is done with hand tools.)

   B. Specialized tool--Tool designed for a particular use

   C. Screwdriver--Tool designed for tightening or loosening a screw or bolt with a recess opening in the head

   D. Wrench--Tool designed to tighten or loosen bolts or nuts

   E. Pipe wrench--Tool used for gripping and turning a cylindrical object

   F. Pliers--Tool with adjustable jaws used for gripping

   G. Hammer--Tool designed to drive, pound, flatten, or shape an object

II. Basic hand tools needed for maintenance and repair (Transparencies 1, 2, 3, 4, and 5)

   A. Basic hand tool assortment

      1. Hammers

         a. Ball peen - one pound

         b. Soft face

      2. Pliers

         a. Slip joint

         b. Diagonal cutting

         c. Lock ring

         d. Needle nose

         e. Snap ring

         f. Vise grip

INFORMATION SHEET

3. Screwdrivers
    a. Standard slot type
        1. 4 inch
        2. 1 1/2 inch
        3. 6 inch
        4. 8 inch
    b. Phillips
        1. 1 1/2 inch
        2. 6 inch
        3. 8 inch
    c. Offset
    d. Clutch head
4. Wrenches
    a. Adjustable
    b. Allen-Set 5/64" to 1/4"
    c. Open-end set including 3/8", 7/16", 1/2", 5/8" and 9/16"
    d. Torque-Inch pound 3/8" drive
    e. Combination set 7/16" to 7/8"
    f. Open-end set--Metric
5. Center punch
6. Cold chisel
7. Universal joint
8. Reversible ratchets
    a. 3/8" drive
    b. 1/4" drive

INFORMATION SHEET

9. Socket sets
    a. 3/8" drive standard
    b. 1/4" drive standard
    c. 3/8" drive metric
    d. Spark plug deep--13/16" by 3/8" drive and 3/4" by 3/8" drive
10. Feeler gauges
    a. Flat
    b. Wire
11. File
12. Parts scraper

B. Other tools
1. Battery clamp puller
2. Battery hydrometer
3. Battery post cleaner
4. Battery syringe
5. Parts cleaning brush
6. Wire brush
7. Parts washing container
8. Funnel
9. Flywheel holder
10. Ignition wrench set
11. Thread repair insert

III. Standard overhaul tools (Transparencies 6, 7, 8, and 9)
A. Boring bar
B. Piston ring expander
C. Piston ring groove cleaner

INFORMATION SHEET

D. Power drill

E. Punch and chisel set

F. Ridge reamer

G. Ring compressor

H. Ring groove gauge

I. Steel rule - 6"

J. Twist drill bit

K. Valve grinders

  a. Manual

  b. Power driven

L. Valve lapping tools

  a. Wood handle

  b. Crank handle

M. Valve seat cutters

  a. Manual

  b. Power

N. Valve spring compressor

  a. Small engine

  b. Lever type

O. Telescoping gauge

P. Micrometer

Q. Valve guide reamer

R. Pullers

  1. Bearing

  2. Flywheel

S. Cylinder hone

INFORMATION SHEET

T. Impact driver

U. Clutch wrench

IV. Types of torque wrenches (Transparency 10)

A. Signaling

(NOTE: This is a click type wrench which signals to the operator when the correct torque is reached.)

B. Direct reading

(NOTE: The torque is read directly from a dial indicator or on a scale from a pointer.)

V. Maintenance procedures

A. Screwdrivers

1. Regrind worn or damaged flat blade screwdrivers
2. Discard phillips screwdrivers with damaged heads

B. Pliers

1. Keep pliers clean and rust free
2. Keep cutting edges sharp and smooth
3. Keep pliers working freely
4. Repair or replace damaged handle insulation

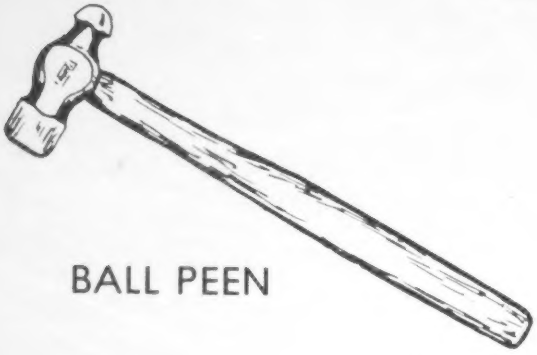
C. Adjustable wrench--Keep worm gears clean and lubricated

D. All tools--Identify tools by labeling them with an electric pencil or scratch awl

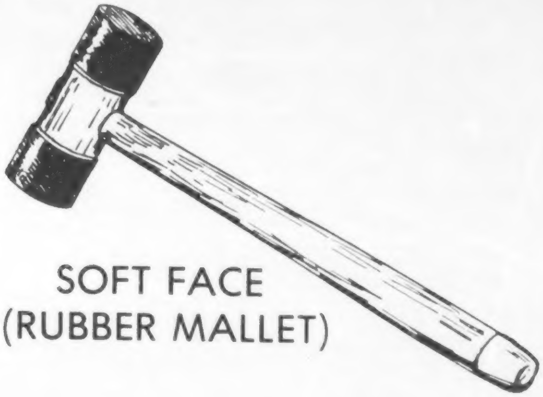
(NOTE: An identification mark can help you distinguish between your tools and someone elses.)

BASIC HAND TOOLS

Hammers

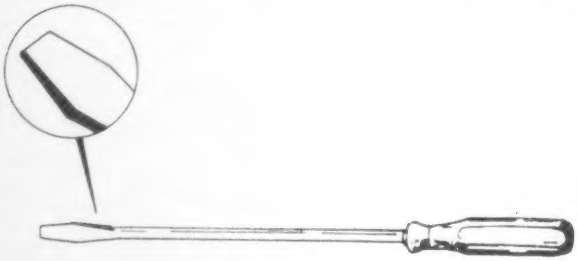


BALL PEEN

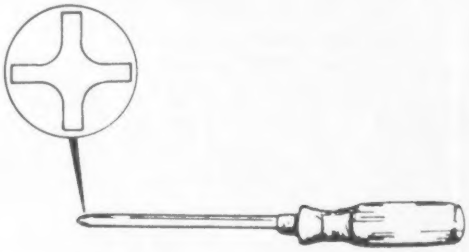


SOFT FACE
(RUBBER MALLET)

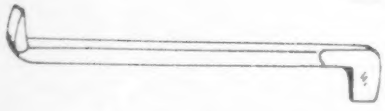
Screwdrivers



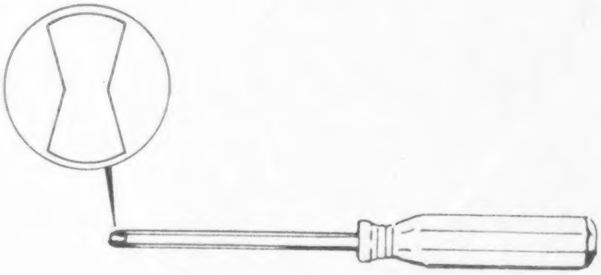
STANDARD SLOT TYPE



PHILLIPS



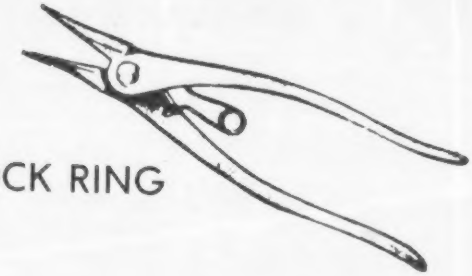
OFFSET



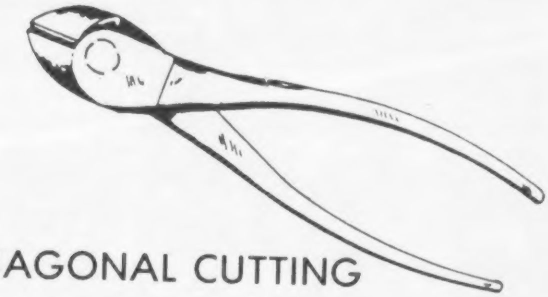
CLUTCH HEAD

BASIC HAND TOOLS
(Continued)

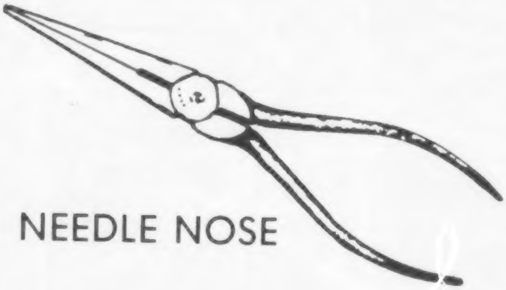
Pliers



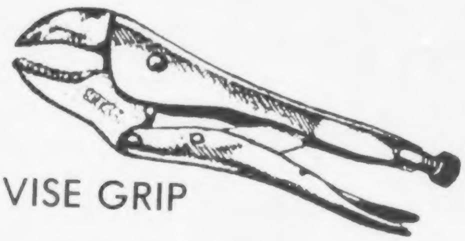
LOCK RING



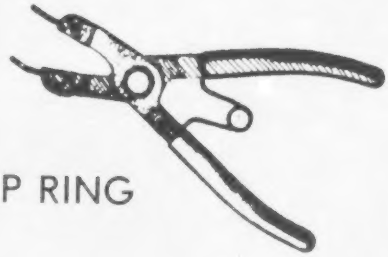
DIAGONAL CUTTING



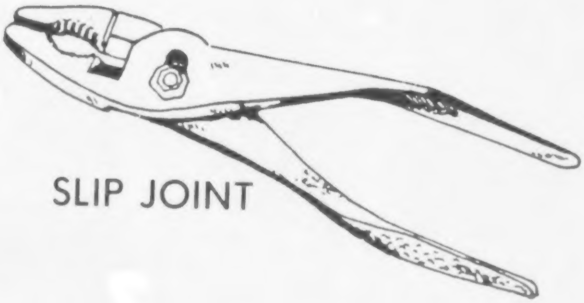
NEEDLE NOSE



VISE GRIP



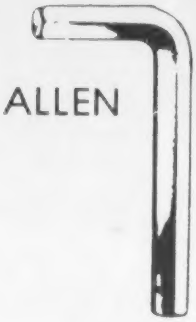
SNAP RING

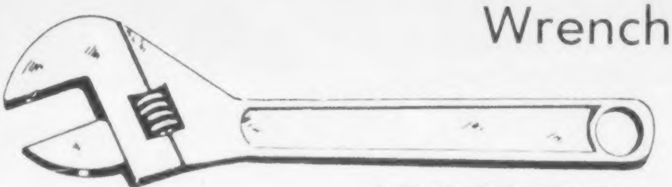


SLIP JOINT

BASIC HAND TOOLS
(Continued)

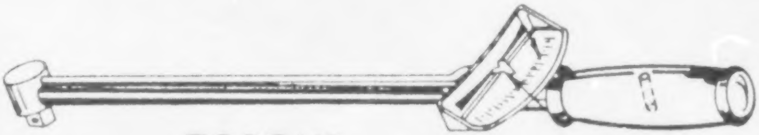
Wrenches

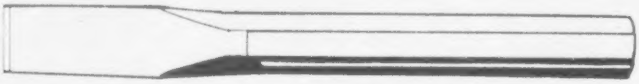

ALLEN

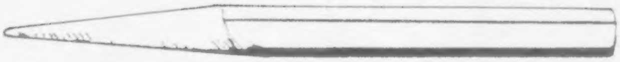

ADJUSTABLE

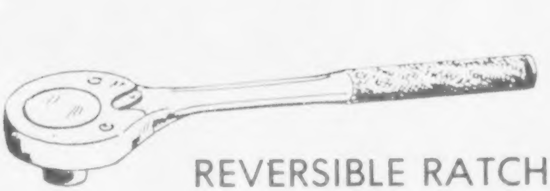
OPEN-END

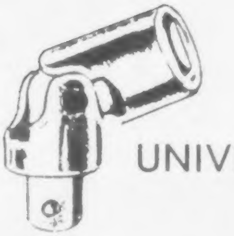
COMBINATION


TORQUE

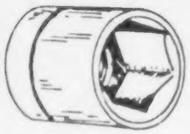

COLD CHISEL


CENTER PUNCH

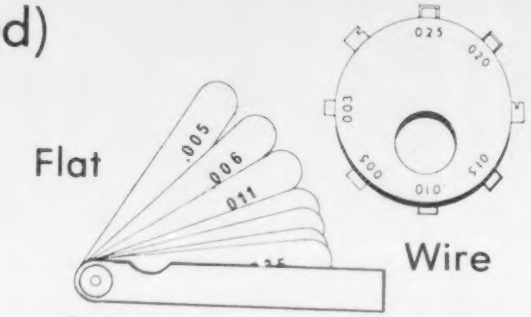

REVERSIBLE RATCHET


UNIVERSAL JOINT

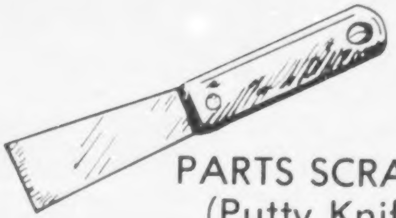
BASIC HAND TOOLS
(Continued)



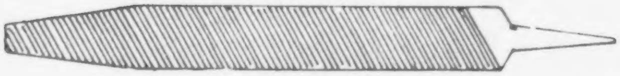
SOCKET


Flat
.005
.006
.011
Wire
025
020
003
015
010
005

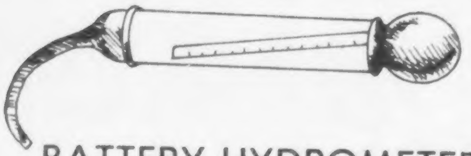
FEELER GAUGES



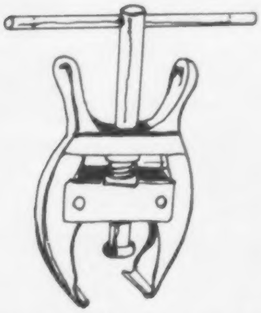
PARTS SCRAPER
(Putty Knife)



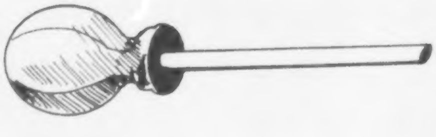
FILE



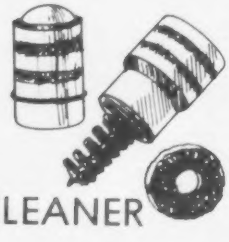
BATTERY HYDROMETER



BATTERY CLAMP PULLER

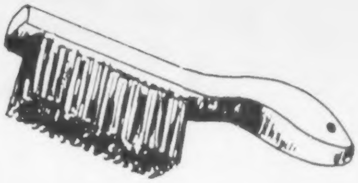


BATTERY SYRINGE

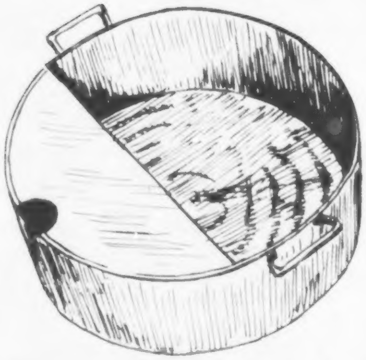


BATTERY POST CLEANER

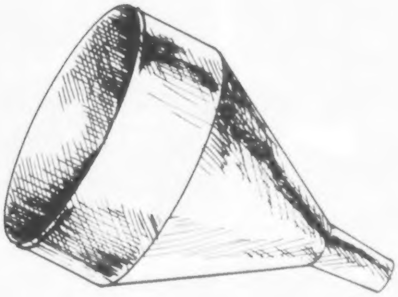
BASIC HAND TOOLS
(Continued)



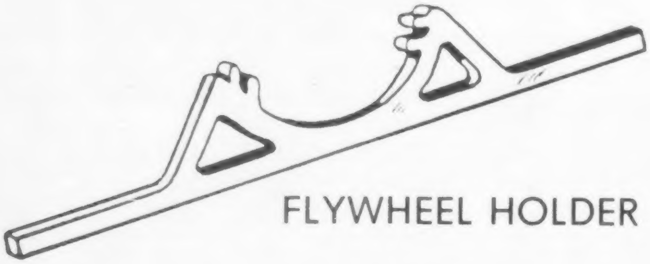
WIRE BRUSH



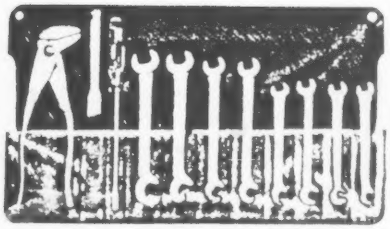
PARTS WASHING CONTAINER



FUNNEL

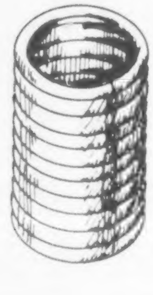


FLYWHEEL HOLDER



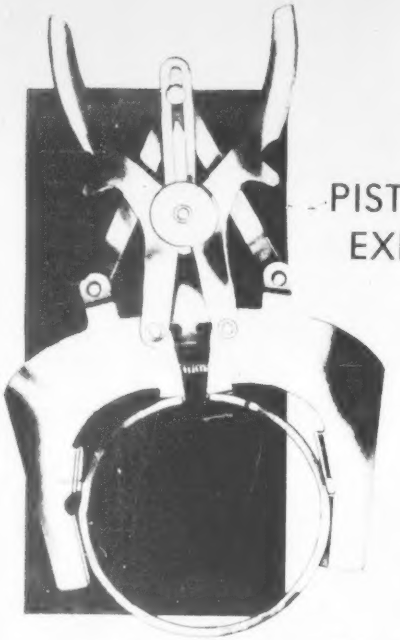
IGNITION WRENCH SET

PARTS CLEANING BRUSH

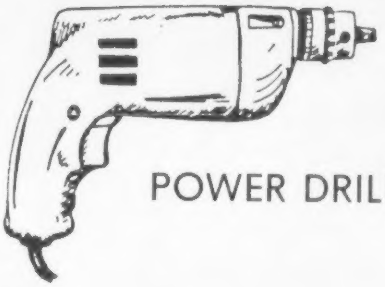


THREAD REPAIR INSERT

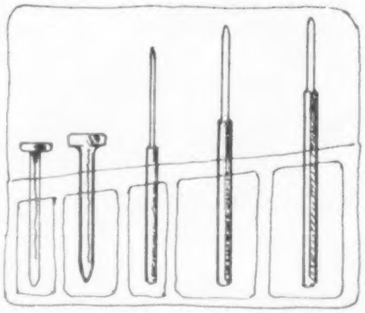
OVERHAUL TOOLS



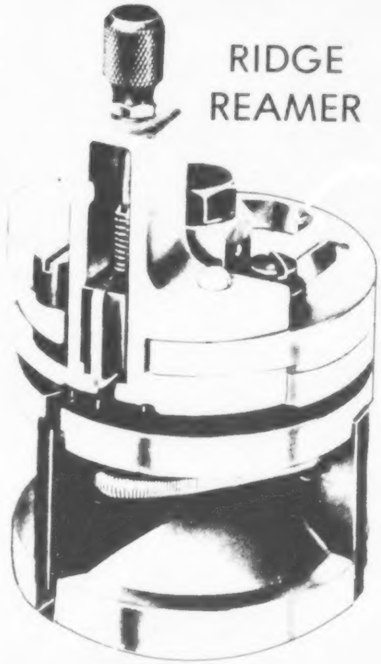
PISTON RING EXPANDER



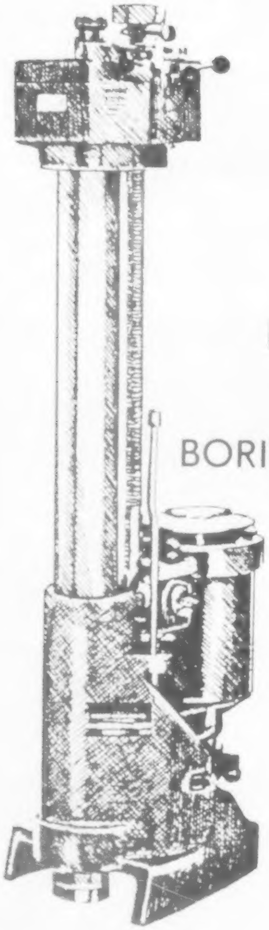
POWER DRILL



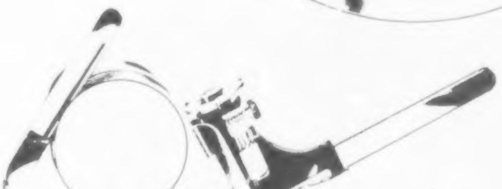
PUNCH AND CHISEL SET



RIDGE REAMER

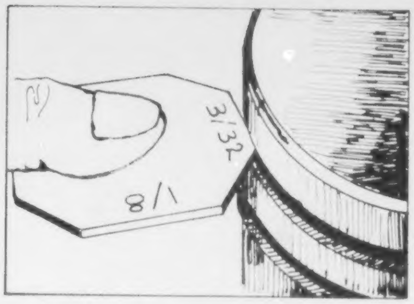


BORING BAR

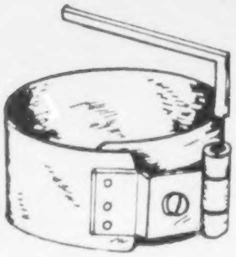


PISTON RING GROOVE CLEANER

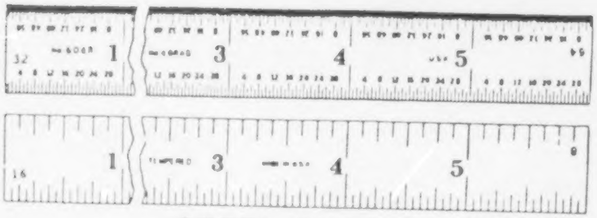
OVERHAUL TOOLS
(Continued)



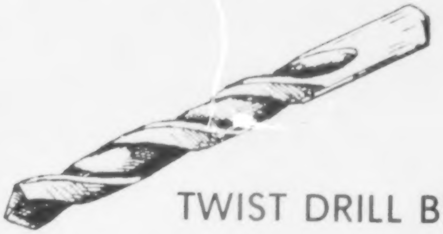
RING GROOVE GAUGE



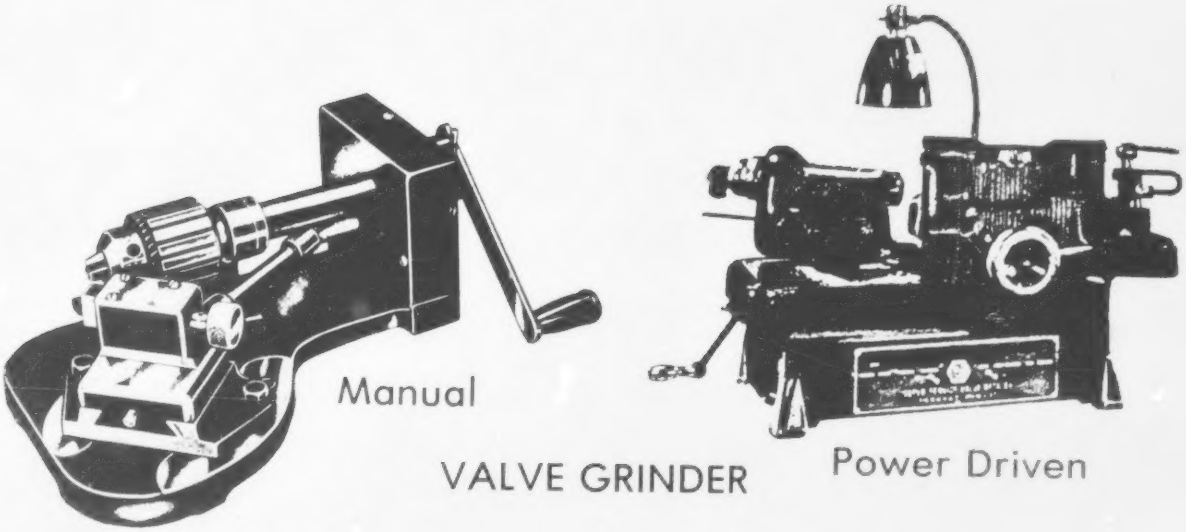
RING COMPRESSOR


32
1
3
4
5
64
16
1
3
4
5
8

STEEL RULE



TWIST DRILL BIT



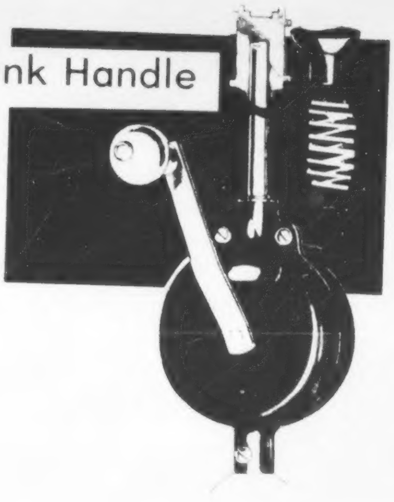
Manual

Power Driven

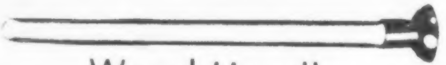
VALVE GRINDER

OVERHAUL TOOLS
(Continued)

VALVE LAPPING TOOL

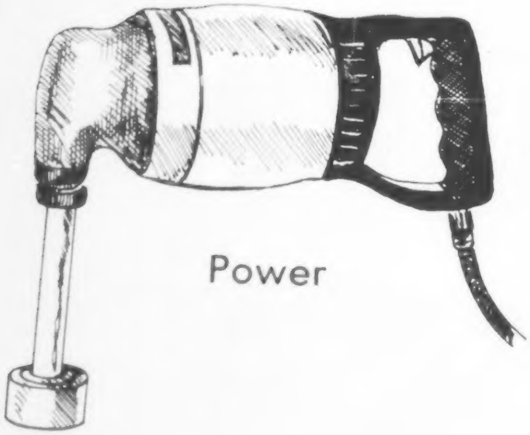


Crank Handle

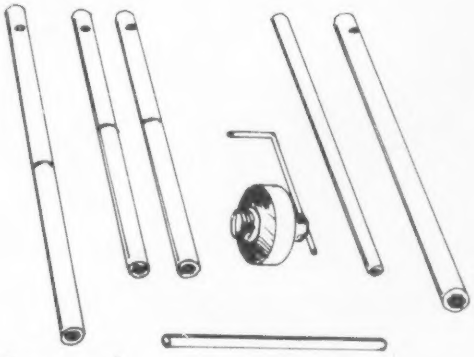


Wood Handle

VALVE SEAT CUTTER

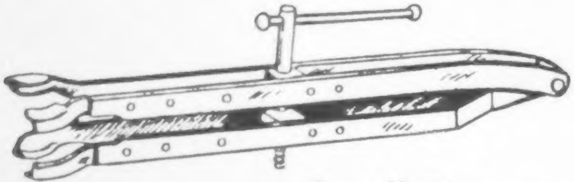


Power

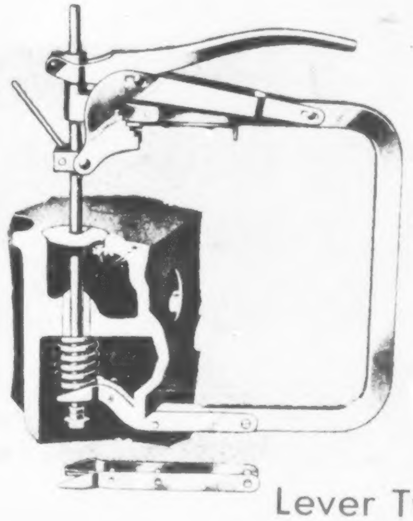


Manual

VALVE SPRING COMPRESSOR

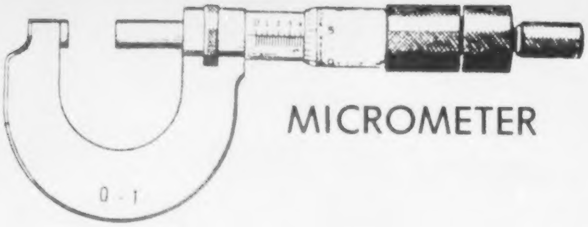


Small Engine

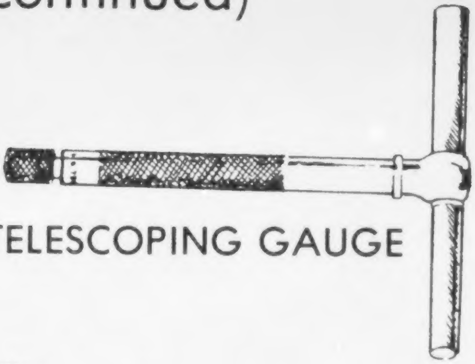


Lever Type

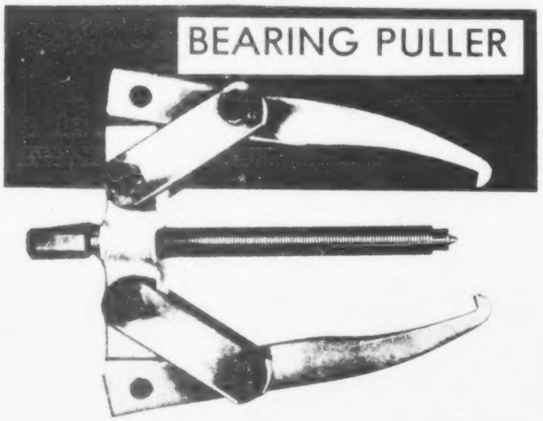
OVERHAUL TOOLS
(Continued)



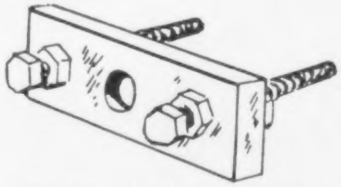
MICROMETER



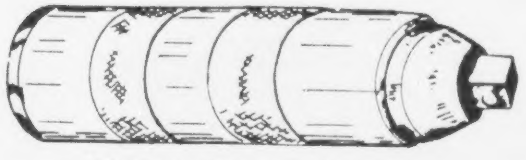
TELESCOPING GAUGE



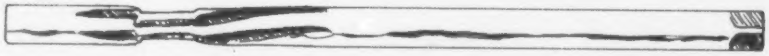
BEARING PULLER



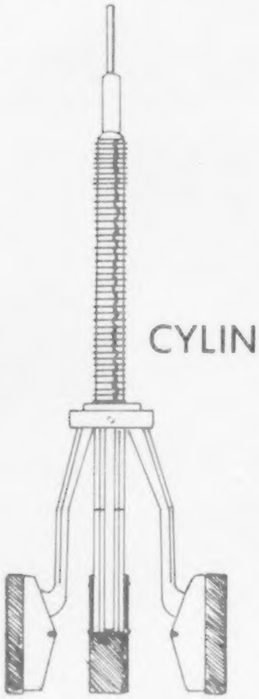
FLYWHEEL PULLER



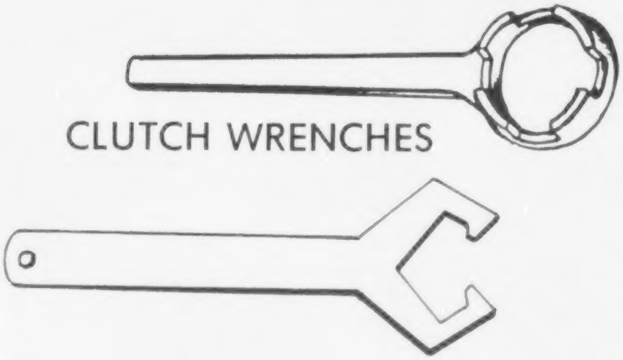
IMPACT DRIVER



VALVE GUIDE REAMER

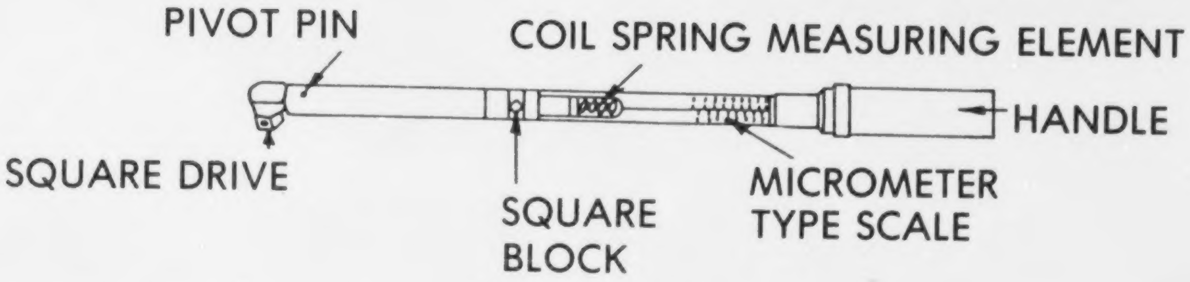


CYLINDER HONE

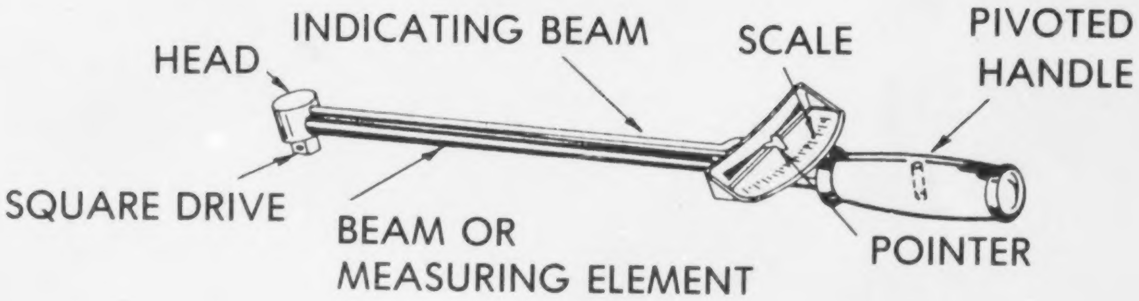


CLUTCH WRENCHES

TORQUE WRENCHES


PIVOT PIN
COIL SPRING MEASURING ELEMENT
HANDLE
SQUARE DRIVE
SQUARE BLOCK
MICROMETER TYPE SCALE

Signaling


HEAD
INDICATING BEAM
SCALE
PIVOTED HANDLE
SQUARE DRIVE
BEAM OR MEASURING ELEMENT
POINTER

Direct Reading

TOOLS
UNIT III

JOB SHEET #1--GRIND A FLAT TIP SCREWDRIVER

I. Tools and materials

   A. Flat tip screwdriver

   B. Bench grinder

   C. Water tray

   D. Safety glasses

II. Procedure

   A. Put on safety glasses

   B. Adjust clearance of tool rest

   (NOTE: Proper clearance is approximately one-eighth inch from grinding wheel.)

   C. Turn on grinder

   (NOTE: Dress grinding wheel if necessary.)

   D. Grind tip of blade flat (Figure 1)

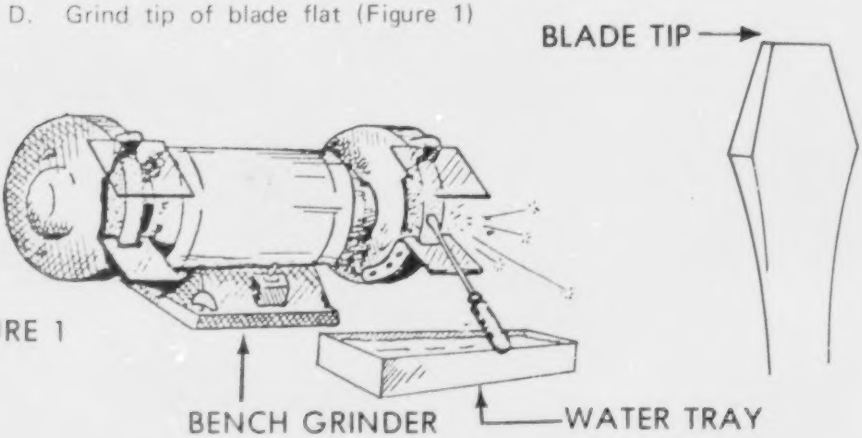


FIGURE 1

E. Grind sides of blade to manufacturer's original specifications (Figure 2)

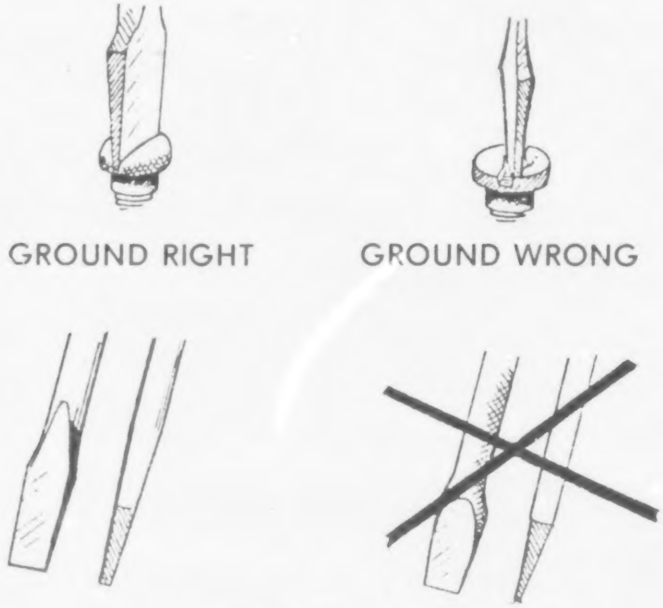

GROUND RIGHT
GROUND WRONG

FIGURE 2

(NOTE: Cool tip in tray of water often while grinding to prevent softening of the tip.)

TOOLS
UNIT III

JOB SHEET #2-GRIND THE HEAD OF CHISEL OR PUNCH

I. Tools and materials

A. Chisel and/or punch

B. Bench grinder

C. Water tray

D. Safety glasses

II. Procedure

A. Put on safety glasses

B. Adjust clearance of tool rest

(NOTE: Proper clearance is approximately one-eighth inch from grinding wheel.)

C. Turn on grinder

(NOTE: Dress grinding wheel if necessary.)

D. Grind a bevel on the head (Figure 1)

(CAUTION: When the head of a punch or chisel is mushroomed, chips could break off during use causing injury to the user.)

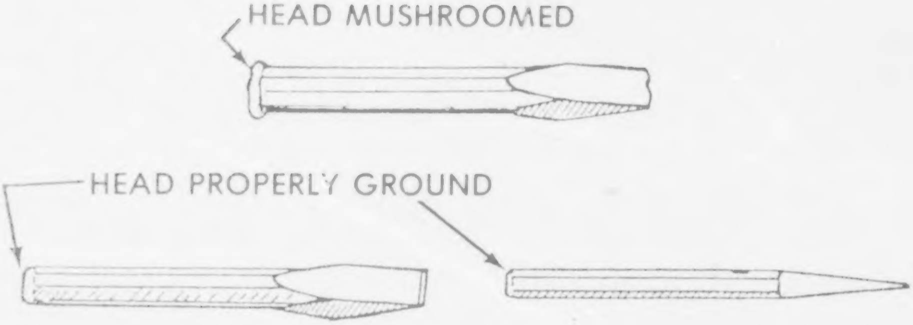


FIGURE 1

TOOLS
UNIT III

JOB SHEET #3--SHARPEN A CHISEL

I. Tools and materials

  A. Chisel

  B. Bench grinder

  C. Water tray

  D. Safety glasses

II. Procedure

  A. Put on safety glasses

  B. Adjust clearance of tool rest

  (NOTE: Proper clearance is approximately one-eighth inch from grinding wheel.)

  C. Turn on grinder

  D. Hold the chisel's cutting edge against the grinding wheel with very little pressure

  (NOTE: This will help to prevent overheating of the chisel's cutting edge. Dip the chisel in the water frequently to cool.)

  E. Grind the edge on a slight curve (Figure 1)

  (CAUTION: Hold the chisel with a firm grip during the grinding process.)

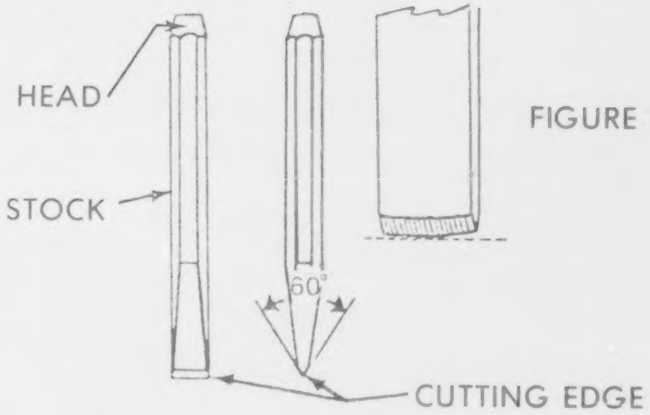


FIGURE 1

TOOLS
UNIT III

JOB SHEET #4--REPAIR DAMAGED THREADS USING A THREAD REPAIR KIT

I. Tools and materials

  A. Safety glasses

  B. Thread repair kit

  C. Drill motor

II. Procedure

  A. Drill out old threads using exact size drill (Figure 1)

  (NOTE: Refer to instructions provided in thread repair kit.)

  B. Drill all the way through an open hole or all the way to bottom of blind hole

  (NOTE: Make sure hole is straight and that centerline of hole is not moved in drilling process.)

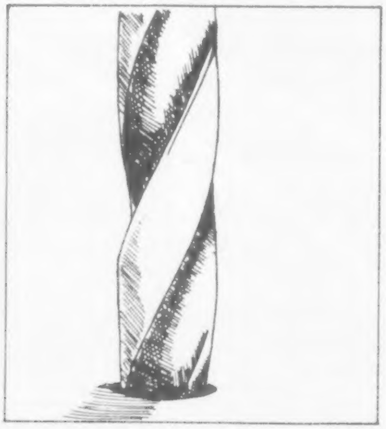


FIGURE 1

JOB SHEET #4

C. Tap out drilled holes (Figure 2)

(NOTE: Special drill taps are provided in thread repair kit for threading drilled hole to correct size for outside of thread insert. A standard tap cannot be used.)

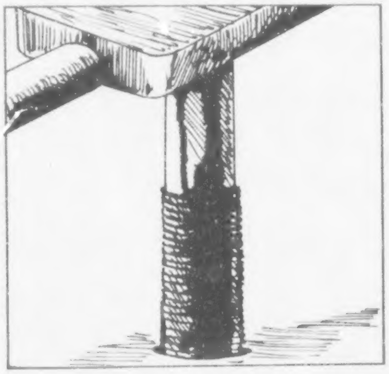


FIGURE 2

D. Install thread repair insert using appropriate tool (Figure 3)

(NOTE: Special tools are provided in thread repair kit for installation of thread insert.)

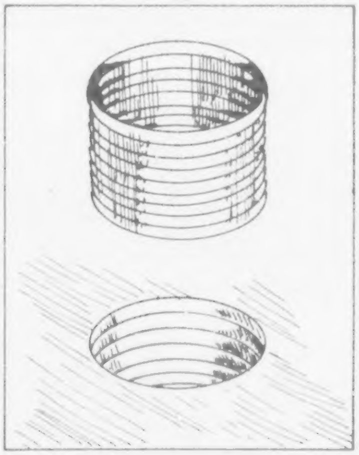


FIGURE 3

TOOLS
UNIT III

JOB SHEET #5--CHECK TORQUE WRENCH FOR ACCURACY

I. Tools and materials

A. Torque wrench

B. Vise

C. "Known" weight

(NOTE: Weight should be at least one-third the capacity of the torque wrench.)

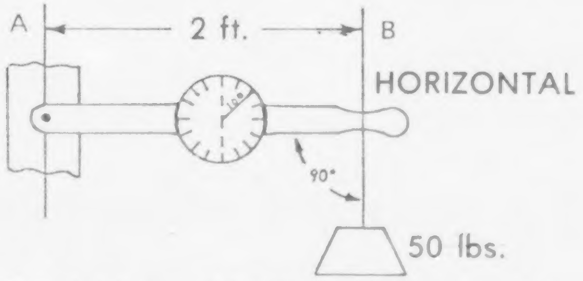
D. Strong cord

II. Procedure

(NOTE: Torque wrenches come in inch pounds and foot pounds. Adjust this job sheet accordingly for inch pound torque wrenches.)

A. Place torque wrench on a fixed nut or secure in a vise (Figure 1)

FIGURE 1



A = CENTER LINE OF NUT B = POINT OF SUSPENSION

B. Set the indicator to "0", if necessary

C. Hang a known weight from the wrench handle at the center of the hand grip area (Figure 1)

D. Multiply the weight times the distance from A to B (Figure 1)

E. Compare the answer to the indicator reading

(NOTE: Using the example in Figure 1, 50 pounds x 2 feet = 100 foot pounds.)

TOOLS
UNIT III

JOB SHEET #6–REPLACE A HAMMER HANDLE

I. Tools and materials

A. Hammer with a broken handle

B. Hacksaw

C. Twist drill

D. Punch

E. Rasp

F. Handsaw

G. Soft-faced hammer

H. Vise

(NOTE: Cover the jaws of the vise with sheet metal or use wood blocks to prevent damage to the hammer and handle.)

I. New handle

J. Small piece of wood for wedge

K. Safety glasses

II. Procedure

A. Place the hammer head in the vise

B. Saw the broken handle close to the hammer head with a hacksaw (Figure 1)

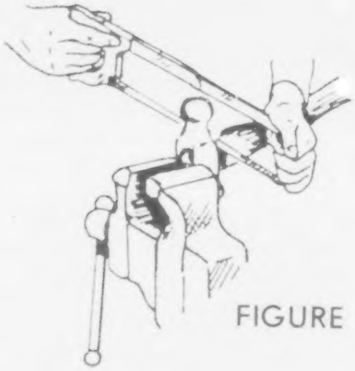


FIGURE 1

JOB SHEET #6

C. Remove the wood from the eye by first drilling with a twist drill and then punching out the remainder (Figure 2)

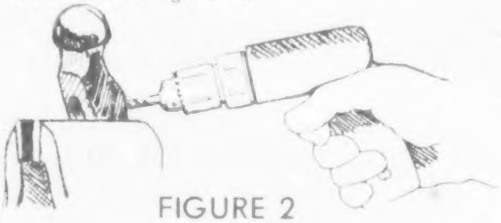


FIGURE 2

D. Place the new handle in the vise

E. Work the new handle down to size with a rasp, trying the handle in the head frequently (Figure 3)

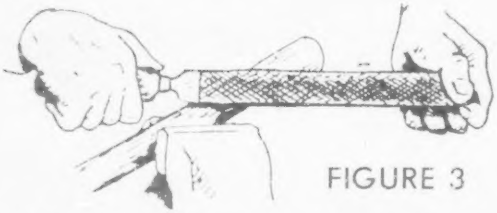


FIGURE 3

F. Make a cut across the long distance of the top of the handle to a distance of about 2/3 the depth of the eye using the handsaw (Figure 4)

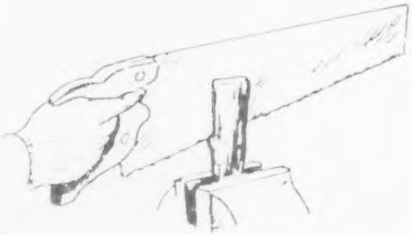


FIGURE 4

G. Drive the handle firmly into place using a soft-faced hammer (Figure 5)

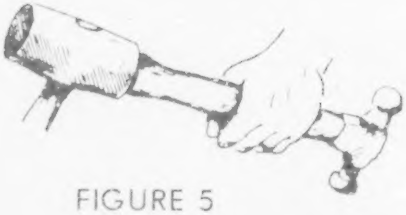


FIGURE 5

JOB SHEET #6

H. Make a thin metal wedge and drive it tightly into the cut in the end of the handle

I. Place the hammer in the vise and use a hacksaw to cut off the handle and wedge extending through the head (Figure 6)

(NOTE: If steel wedges are used, the end of the handle need not be cut across the diameter because the wedge can be driven into place after the handle has been cut off even with the head.)

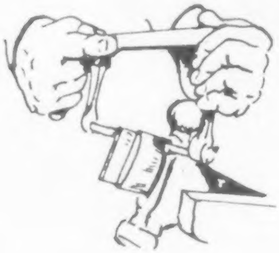


FIGURE 6

TOOLS
UNIT III

NAME______________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Tool designed to drive, pound, flatten, or shape an object

_____b. Tool with adjustable jaws used for gripping

_____c. Tool designed to tighten or loosen bolts or nuts

_____d. Tool designed for tightening or loosening a screw or bolt with a recess opening in the head

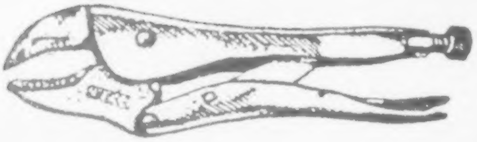
_____e. Tool designed for a particular use

_____f. Tool which is hand held and is not electrical or specialized

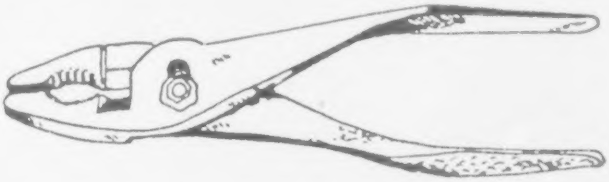
_____g. Tool used for gripping and turning a cylindrical object

1. Pliers
2. Wrench
3. Hand tool
4. Hammer
5. Specialized tool
6. Pipe wrench
7. Screwdriver

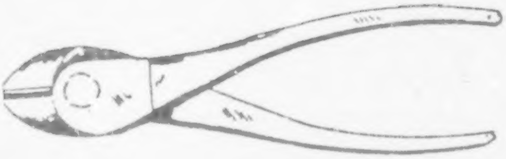
2. Identify the basic hand tools needed for maintenance and repair of small engines.



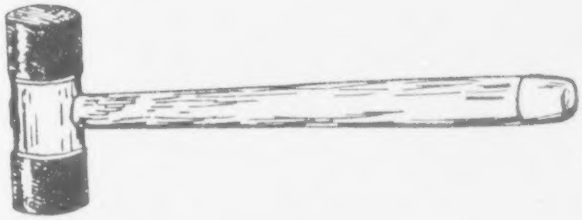
a. ______________________



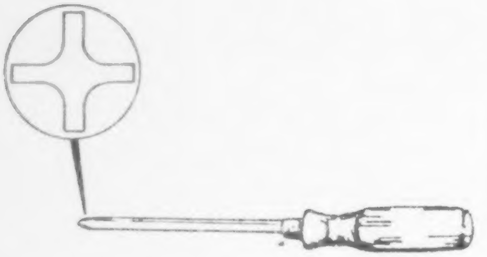
b. ______________________



c. ______________________

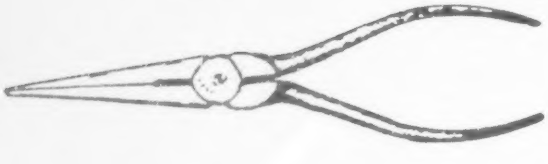


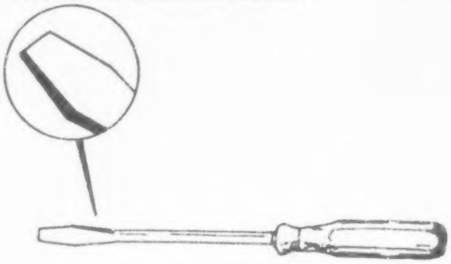
d. ______________________



e. ____________________

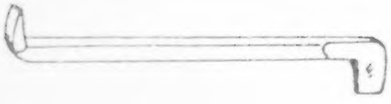
f. ____________________

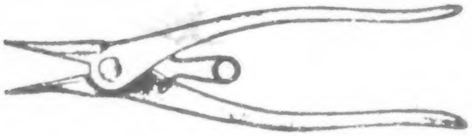




g. ____________________

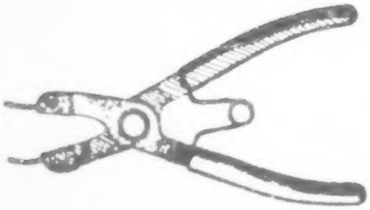
h. ____________________

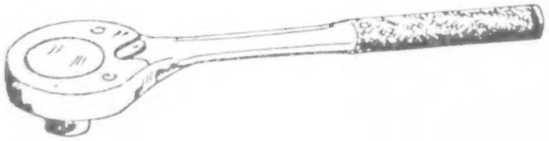




i. ____________________

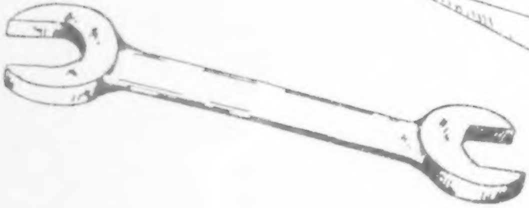
j. ____________________

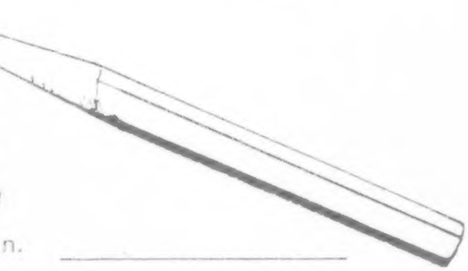




k. ____________________

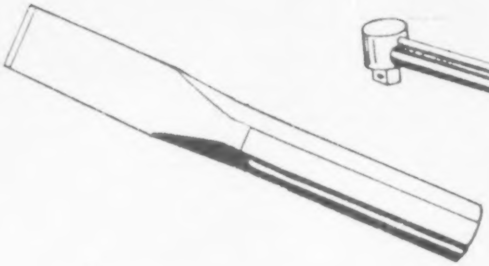
l. ____________________

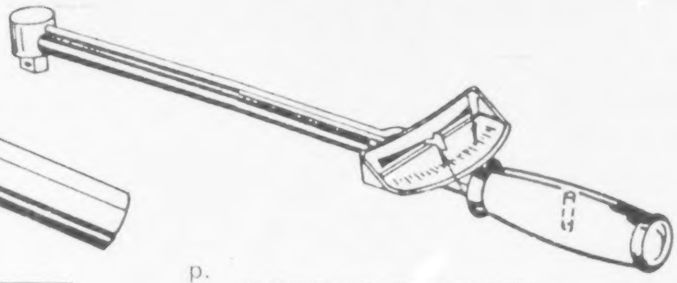




m. ____________________

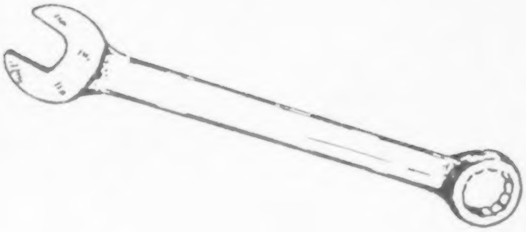
n. ____________________

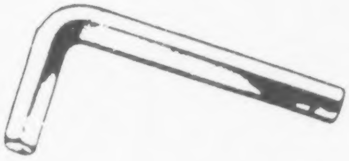




o. ______________

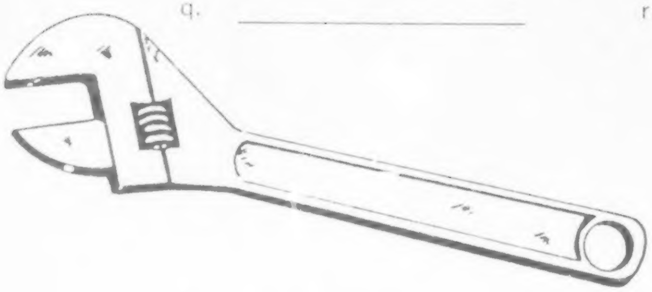
p. ______________

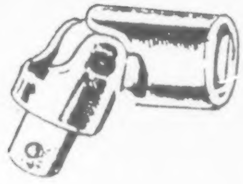




q. ______________

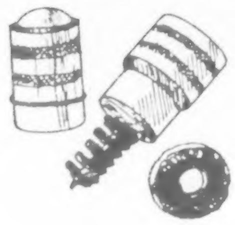
r. ______________

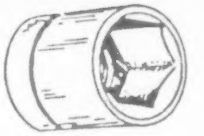




s. ______________

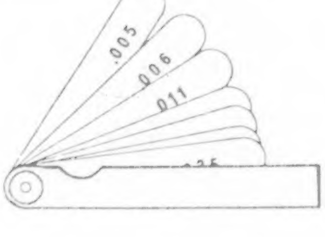
t. ______________





u. ______________

v. ______________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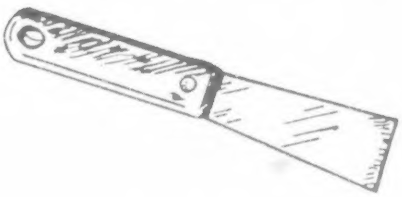

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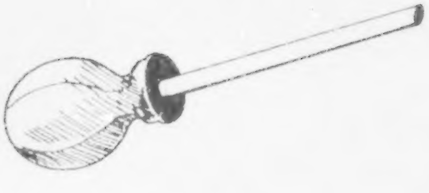

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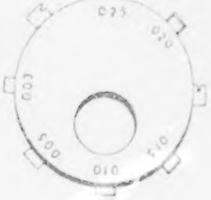
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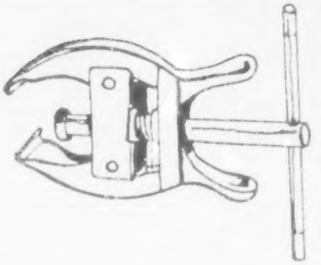

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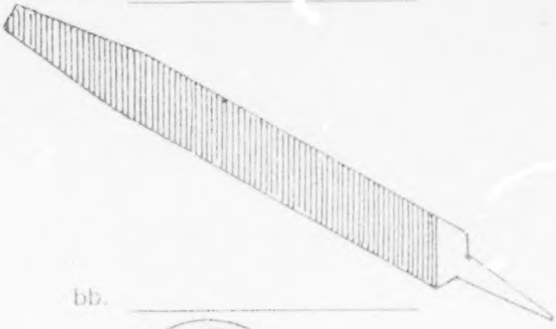

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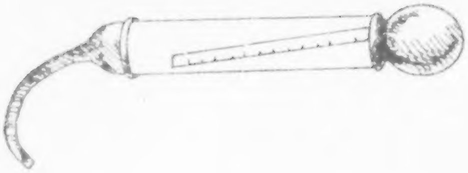

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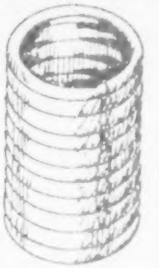

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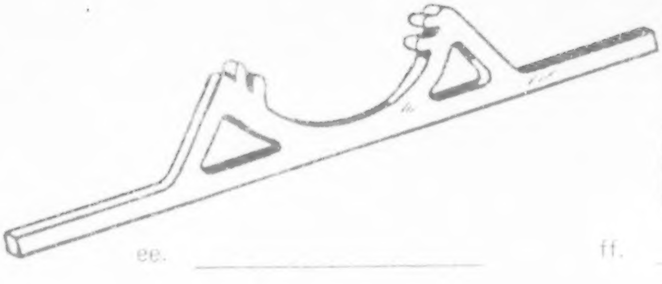

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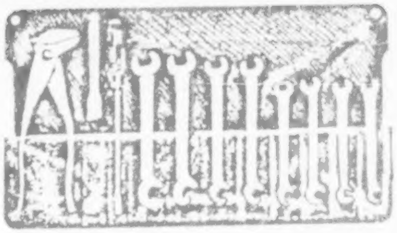

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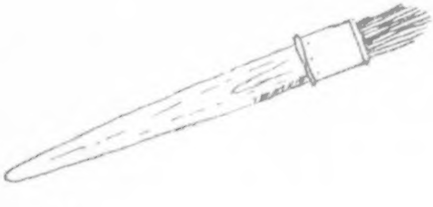

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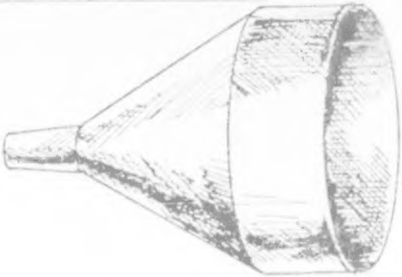

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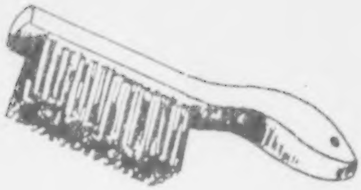

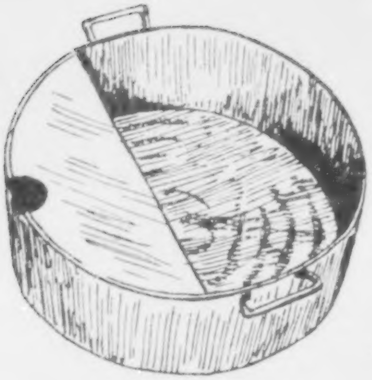

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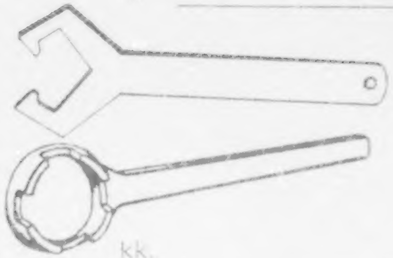
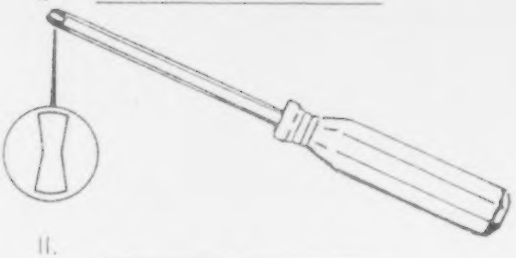
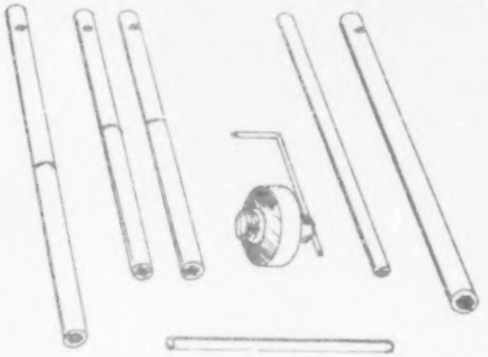


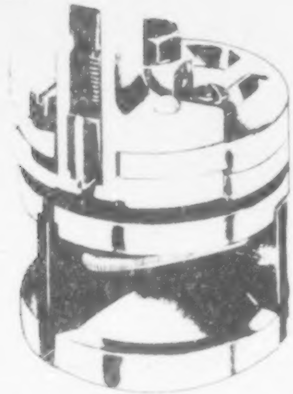


kk. ____________________

ll. ____________________

3. Identify the tools used for overhaul of small engines.





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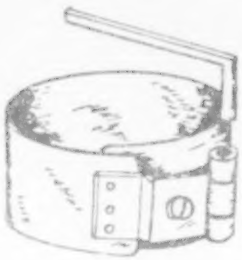

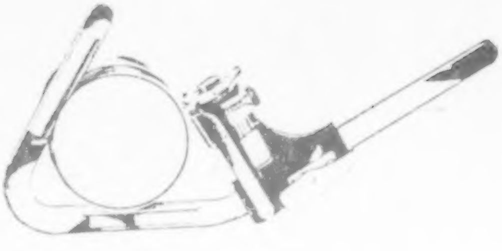

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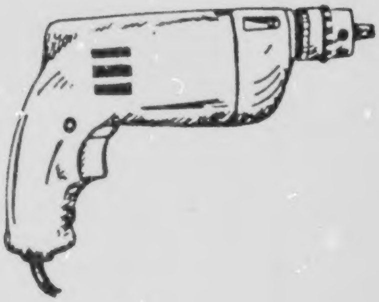

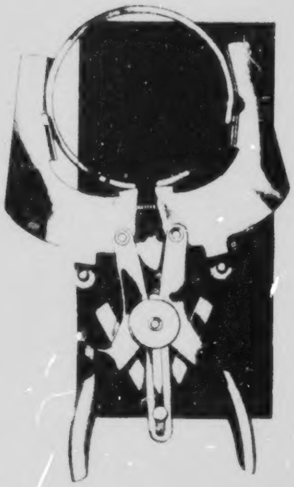

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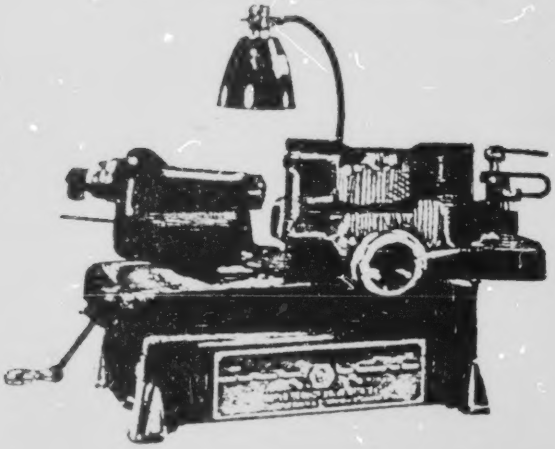

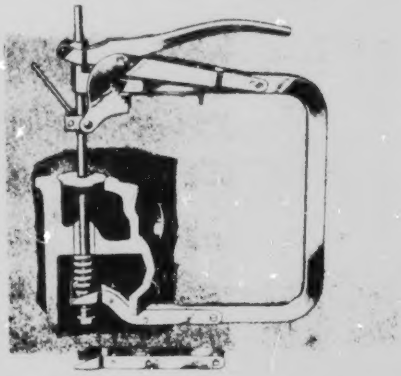

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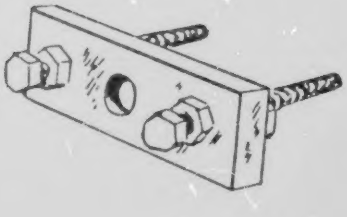

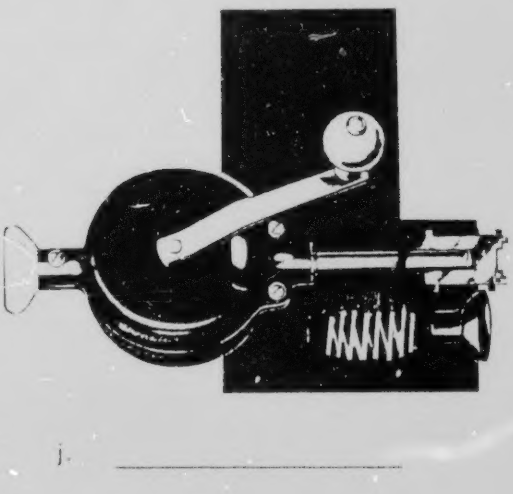

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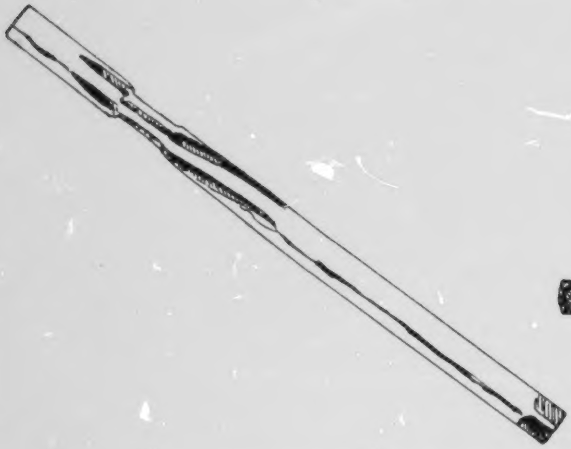

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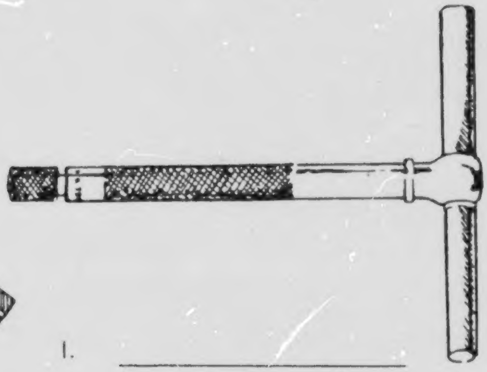

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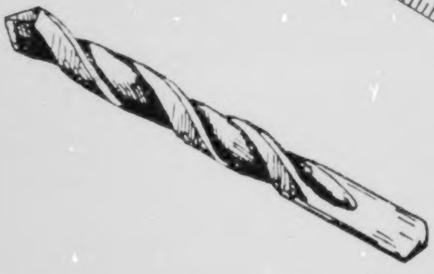

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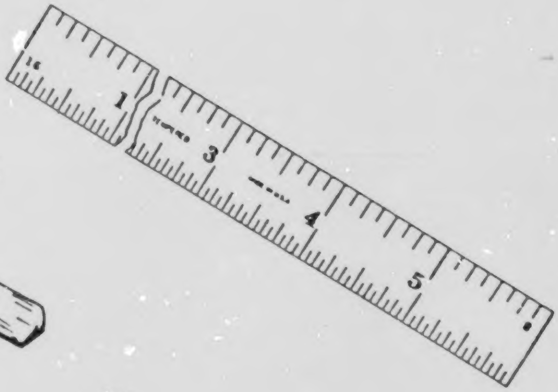

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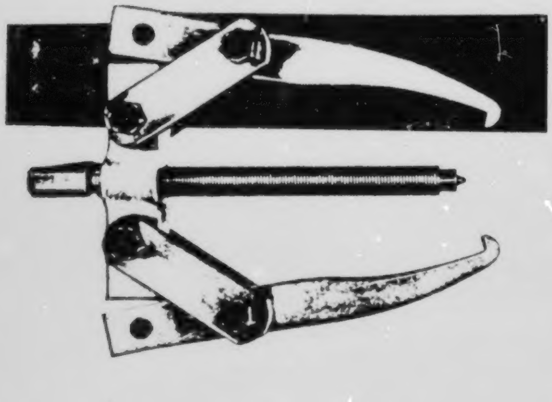

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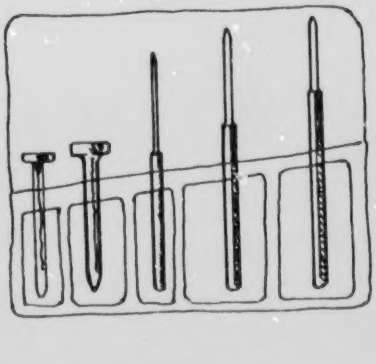

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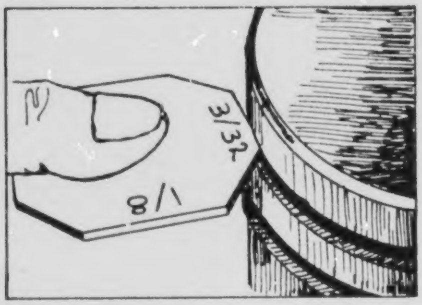

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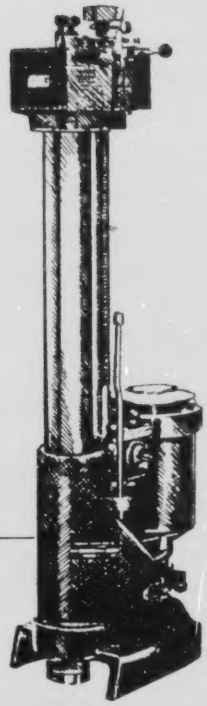

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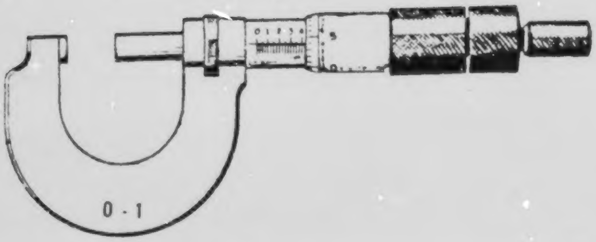

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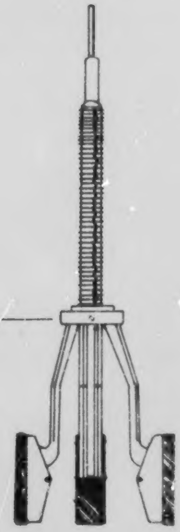

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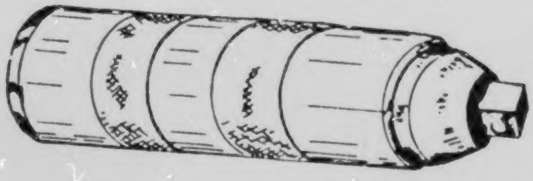
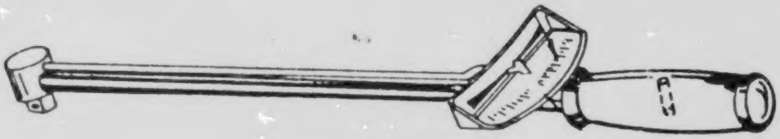
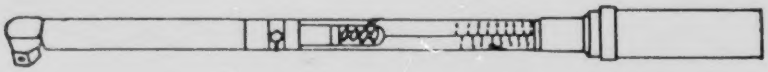


u. ______________________

4. Identify the types of torque wrenches.



a. ____________________



b. ____________________

5. Discuss maintenance procedures for tools.

6. Demonstrate the ability to:
   a. Grind a flat tip screwdriver.
   b. Grind the head of chisel or punch.
   c. Sharpen a chisel.
   d. Repair damaged threads using a thread repair kit.
   e. Check torque wrench for accuracy.
   f. Replace a hammer handle.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

TOOLS
UNIT III

ANSWERS TO TEST

1. a. 4
   b. 1
   c. 2
   d. 7
   e. 5
   f. 3
   g. 6

2. a. Vise grip pliers
   b. Slip joint pliers
   c. Diagonal cutting pliers
   d. Soft face hammer
   e. Phillips screwdriver
   f. Ball peen hammer
   g. Needle nose pliers
   h. Standard slot type screwdriver
   i. Offset screwdriver
   j. Lock ring pliers
   k. Snap ring pliers
   l. Reversible ratchet
   m. Open-end wrench
   n. Center punch
   o. Cold chisel
   p. Torque wrench
   q. Combination wrench
   r. Allen wrench
   s. Adjustable wrench
   t. Universal joint
   u. Battery post cleaner
   v. Socket
   w. Feeler gauge - flat
   x. Parts scraper
   y. Battery syringe
   z. Feeler gauge - wire
   aa. Battery clamp puller
   bb. File
   cc. Battery hydrometer
   dd. Thread repair insert
   ee. Flywheel holder
   ff. Ignition wrench set
   gg. Parts cleaning brush
   hh. Funnel
   ii. Wire brush
   jj. Parts washing container
   kk. Clutch wrench
   ll. Clutch head screwdriver

3. a. Manual valve seat cutter
   b. Ridge reamer
   c. Ring compressor
   d. Piston ring groove cleaner
   e. Power drill
   f. Piston ring expander
   g. Power driven valve grinder
   h. Lever type valve spring compressor
   i. Flywheel puller
   j. Valve lapping tool
   k. Valve guide reamer
   l. Telescoping gauge
   m. Twist drill bit
   n. Steel rule - 6"
   o. Bearing puller
   p. Punch and chisel set
   q. Ring groove gauge
   r. Boring bar
   s. Micrometer
   t. Cylinder hone
   u. Impact driver

4. a. Direct reading
   b. Signaling

5. Discussion should include:
   a. Screwdrivers
      1) Regrind worn or damaged flat blade screwdrivers
      2) Discard phillips screwdrivers with damaged heads
   b. Pliers
      1) Keep pliers clean and rust free
      2) Keep cutting edges sharp and smooth
      3) Keep pliers working freely
      4) Repair or replace damaged handle insulation
   c. Adjustable wrench--Keep worm gears clean and lubricated
   d. All tools--Identify tools by labeling them with an electric pencil or scratch awl

6. Performance skills evaluated to the satisfaction of the instructor.

MEASURING
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to read and use a plain micrometer, a vernier caliper, and a dial indicator. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with measuring to the correct definitions.
2. Identify measuring instruments used in small engine repair.
3. List four steps for reading measuring instruments.
4. Name three basic units of measurement found on rules.
5. Identify the major parts of a vernier caliper.
6. Identify the major parts of an outside micrometer.
7. Discuss the proper methods for checking the accuracy of outside micrometers.
8. Identify the major parts of a dial indicator.
9. Arrange in order the steps for set up and use of a dial indicator.
10. Read plain micrometer settings.
11. Read vernier micrometer settings.
12. Demonstrate the ability to:
    a. Use a vernier caliper.
    b. Use a plain micrometer.
    c. Use a dial indicator.

MEASURING
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information, assignment and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information, assignment and job sheets.
- F. Give test.

II. Student

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete assignment and job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
  1. TM 1-Measuring Instruments
  2. TM 2-Measuring Instruments (Continued)
  3. TM 3-Units of Measurement
  4. TM 4-Vernier Caliper Parts
  5. TM 5-Micrometer Parts
  6. TM 6-Checking the Micrometer for Accuracy
  7. TM 7-Dial Indicator Parts

8. TM 8--Reading a Micrometer
9. TM 9--Sleeve Readings
10. TM 10--Overlay A--Thimble Sleeve Readings
11. TM 11--Vernier Micrometer Readings
12. TM 12--Overlay B--Vernier Sleeve Readings

D. Assignment sheets

1. Assignment Sheet #1--Read the Plain Micrometer Settings
2. Assignment Sheet #2--Read the Vernier Micrometer Settings

E. Answers to assignment sheets

F. Job sheets

1. Job Sheet #1--Use a Vernier Caliper
2. Job Sheet #2--Use a Plain Micrometer
3. Job Sheet #3--Use a Dial Indicator

G. Test

H. Answers to test

II. Reference--Armstrong, Ivan. *Auto Mechanics, Book I.* Stillwater, Oklahoma: State Department of Vocational-Technical Education, 1976.

MEASURING
UNIT IV

INFORMATION SHEET

I. Terms and definitions

   A. Steel rule--Low precision measuring instrument graduated in fractional or decimal parts of an inch

   B. Graduation--Marking found on rules and scales to denote unit of length

   C. Error--Mistake in the reading or total measurement

   D. Reliable measure--Accurate or true measurement

   E. Reference point--Starting point of measurement for both workpiece and rule

   F. Vernier caliper--Makes accurate inside and outside measurements to within one-thousandth of an inch, or one-hundredth of a millimeter

II. Measuring instruments used in small engine repair (Transparencies 1 and 2)

   A. Rule

   B. Vernier caliper

   C. Micrometers

      1. Inside

      2. Outside

      3. Depth

   (NOTE: These can be plain or vernier; plain measures to thousandths of an inch, vernier to ten-thousandths of an inch.)

   D. Dial indicator

   E. Telescoping gauge

   F. Hole gauge

III. Steps for reading measuring instruments

   A. Select scale of the required units

   B. Total the number of graduations

INFORMATION SHEET

C. Count whole units

D. Reduce graduations to lowest terms

IV. Basic units of measurement found on rules (Transparency 3)

A. Fractional

Example: 1/8, 1/16, 1/32

B. Decimal

Example: 0.1, 0.01, 0.001

C. Metric

Example: 1 meter = 1m, 1 millimeter = 1mm

V. Major parts of vernier caliper (Transparency 4)

A. Fixed jaw

B. Movable jaw

C. Beam

D. Clamp

E. Clamp screws

F. Main scale

G. Vernier scale

H. Adjusting nut

VI. Major parts of an outside micrometer (Transparency 5)

A. Frame

B. Anvil

C. Spindle

D. Lock

E. Sleeve

F. Thimble

G. Ratchet stop

INFORMATION SHEET

VII. Proper methods for checking accuracy of outside micrometers (Transparency 5)

A. 0" 1.000"

1. Close spindle and anvil together

2. Observe zero references on the sleeve and thimble

B. More than one inch

1. Use a standard bar or disc to check the minimum capacity

2. Observe zero references on the sleeve and thimble

VIII. Major parts of a dial indicator (Transparency 7)

A. Housing

B. Dial

C. Pointer

D. Plunger

E. Bezel

F. Bezel clamp

IX. Set up and use of a dial indicator

A. Secure dial indicator to suitable mounting fixture

B. Position plunger in contact with surface to be measured

C. Pre-load dial indicator

(NOTE: Pre-loading is accomplished by positioning dial indicator so that plunger is depressed equal to two revolutions of the pointer.)

D. Zero dial

(NOTE: To zero dial rotate bezel until zero mark is in line with end of pointer.)

E. Measure work

INFORMATION SHEET

X. Reading the plain micrometer (Transparencies 8, 9, and 10 [Overlay A])

A. Each numbered graduation on the sleeve represents one-hundred thousandths of an inch (0.100")

B. Each small graduation on the sleeve between the numbered graduations represents twenty-five thousandths of an inch (0.025")

C. Each graduation found on the thimble represents one thousandth of an inch (0.001")

D. Total reading is found by adding the three values

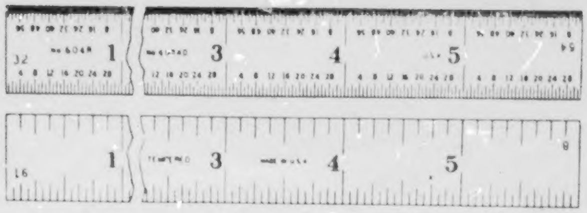
Example:	0.100	Number on the sleeve
	0.075	Small graduations on the sleeve
	0.015	Graduations on the thimble
	0.190	Plain micrometer reading

XI. Reading the vernier micrometer (Transparencies 10 [Overlay A], 11, and 12 [Overlay B])

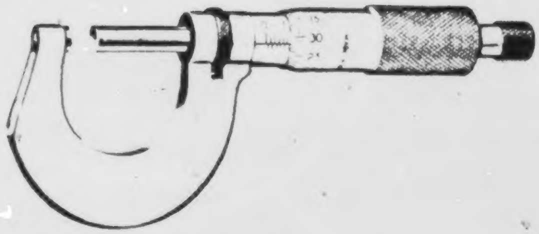
A. Each numbered graduation on the sleeve represents one-hundred thousandths of an inch (0.100")

B. Each small graduation on the sleeve between the numbered graduations represents twenty-five thousandths of an inch (0.025")

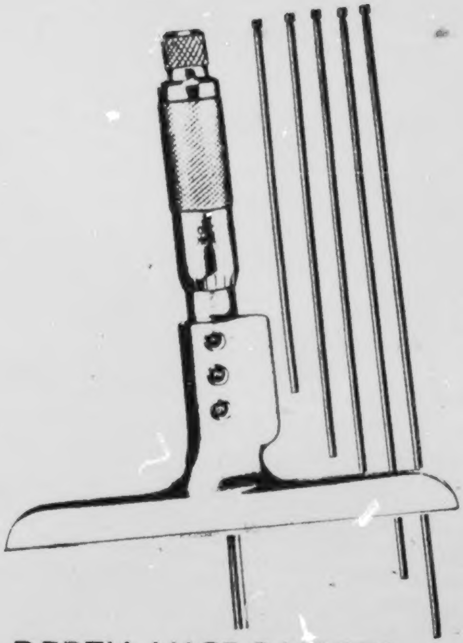
MEASURING INSTRUMENTS



RULES



OUTSIDE MICROMETER



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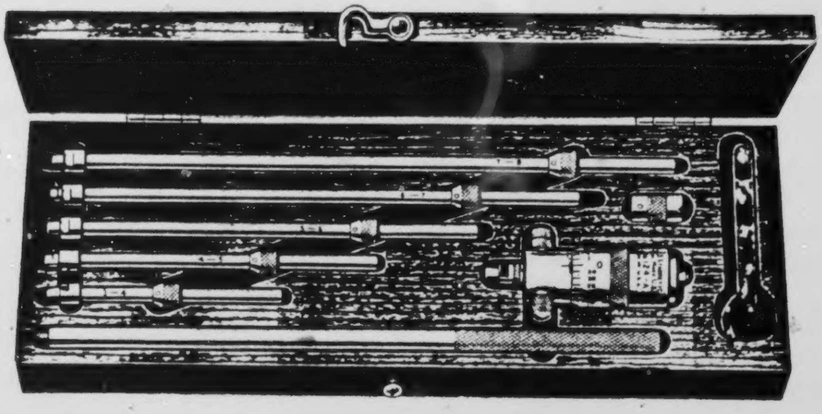
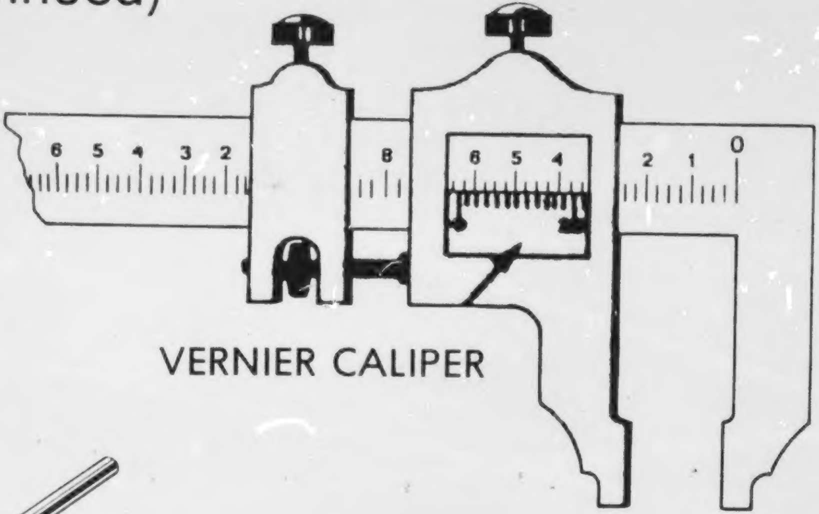


INSIDE MICROMETER

MEASURING INSTRUMENTS
(Continued)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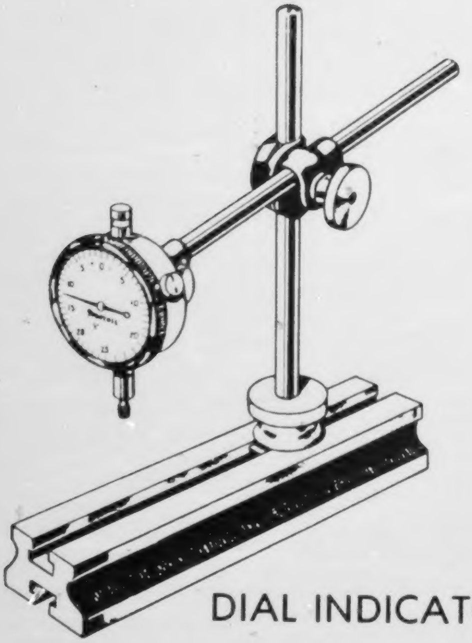
8
6 5 4
2 1 0

VERNIER CALIPER



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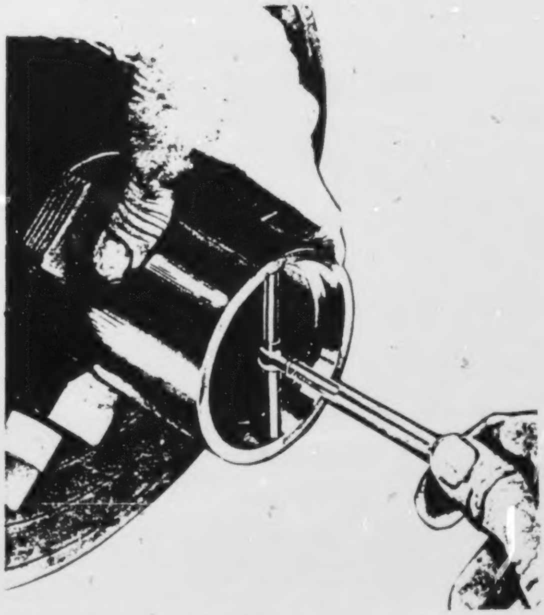
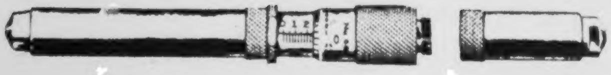
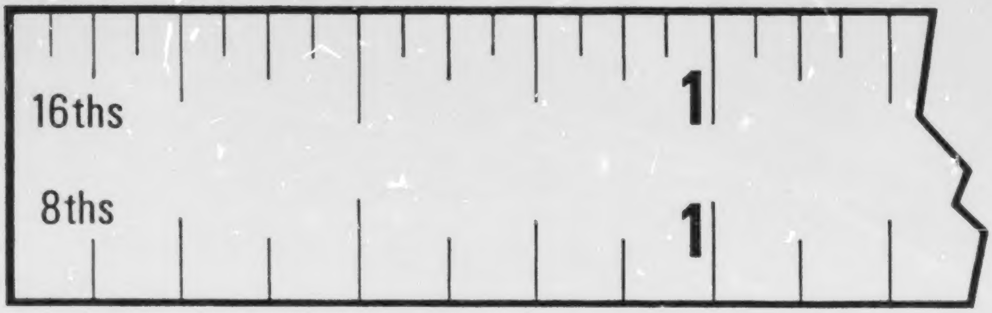


TELESCOPING GAUGE

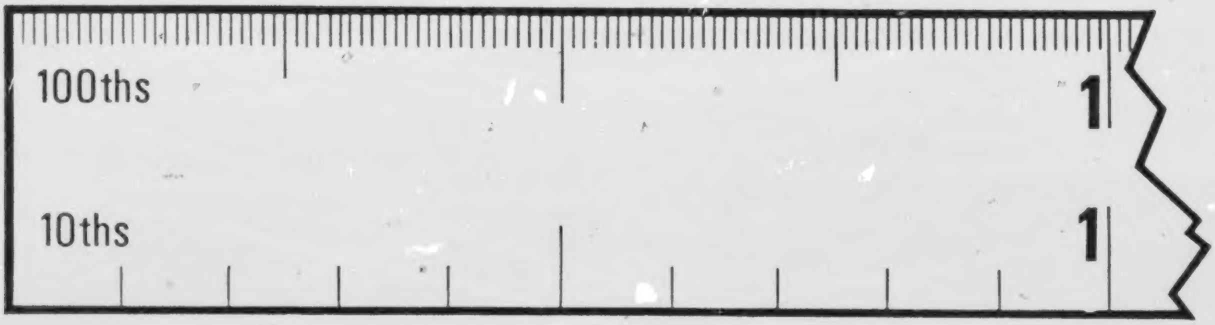


HOLE GAUGE

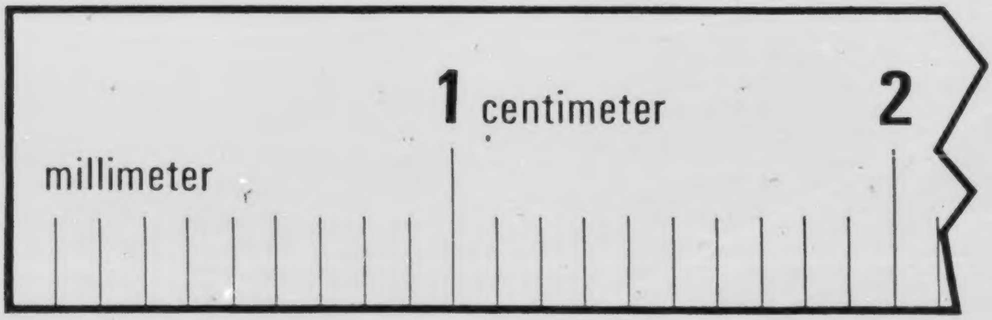
UNITS OF MEASUREMENT


16ths
1
8ths
1

Fractional Rule

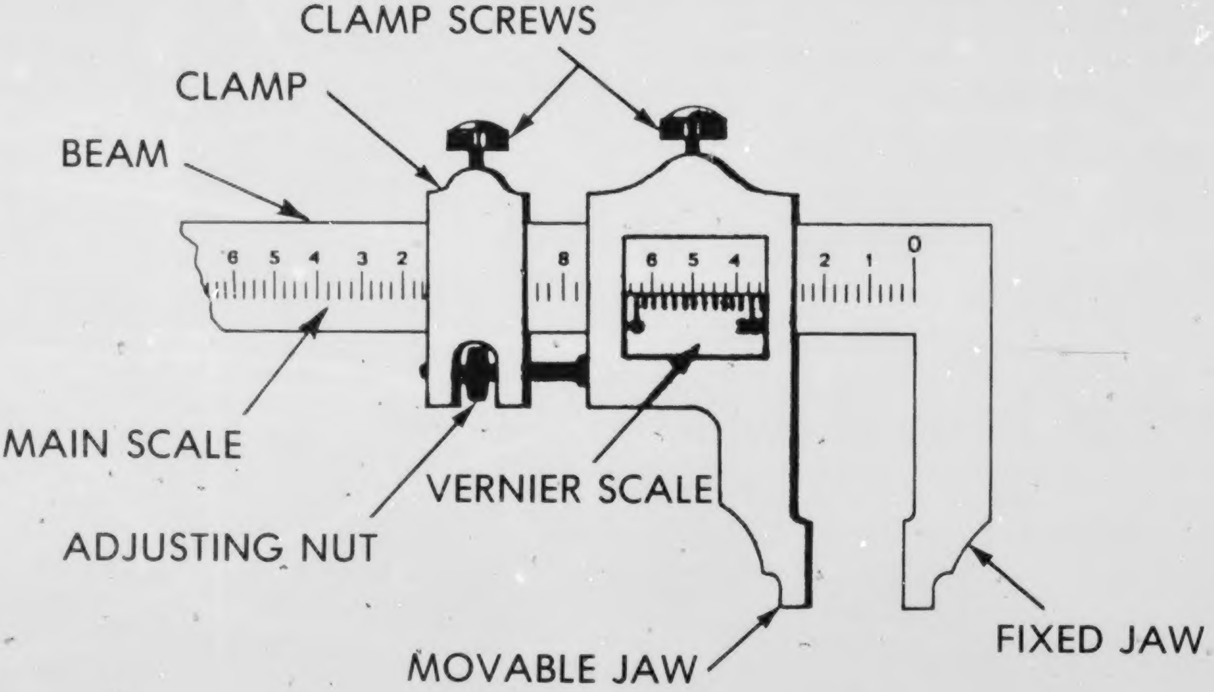

100ths
1
10ths
1

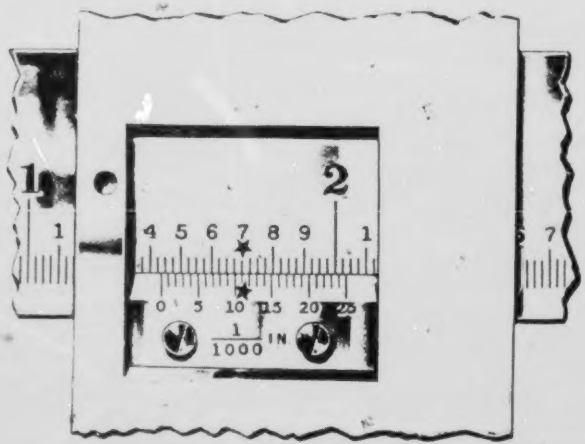
Decimal Rule


1
centimeter
2
millimeter

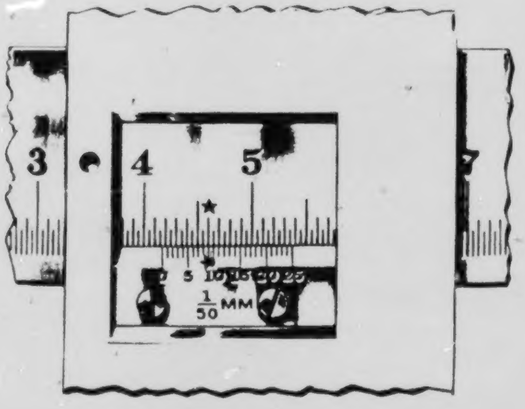
Metric Rule

VERNIER CALIPER PARTS


CLAMP SCREWS
CLAMP
BEAM
6 5 4 3 2
8
6 5 4
2 1 0
MAIN SCALE
VERNIER SCALE
ADJUSTING NUT
MOVABLE JAW
FIXED JAW

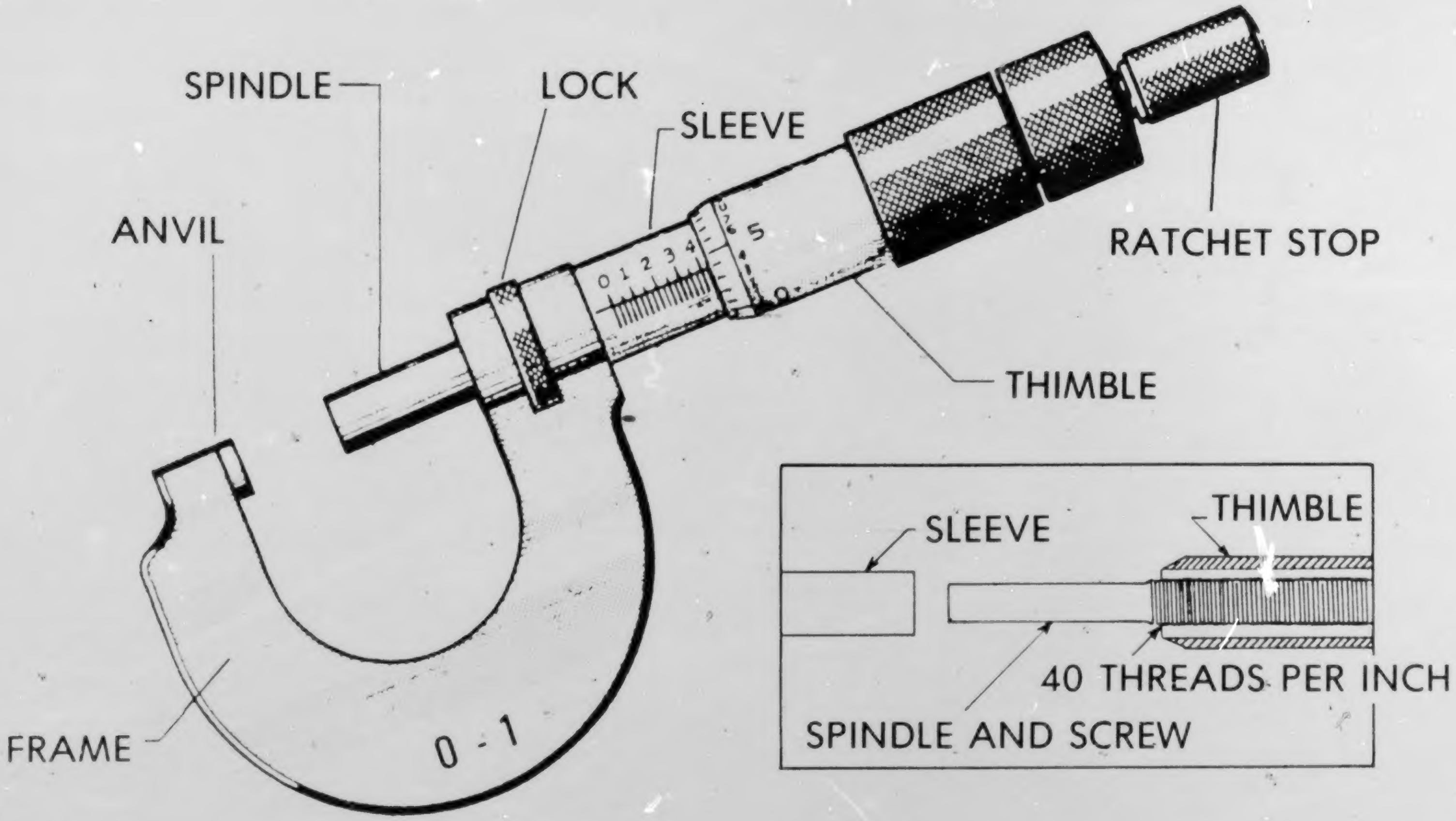

1
2
1
4 5 6 7 8 9 1
6 7
0 5 10 15 20 25
1/1000 IN

STANDARD SCALE

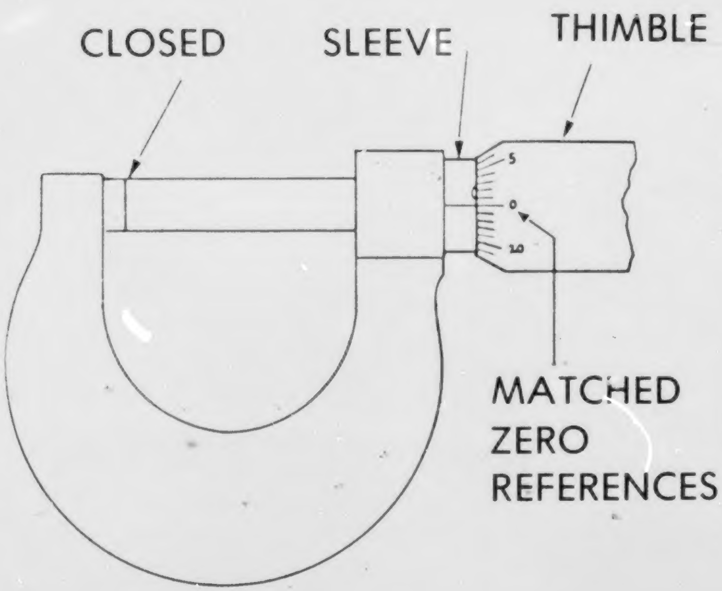

3
4
5
0 5 10 15 20 25
1/50 MM

METRIC SCALE

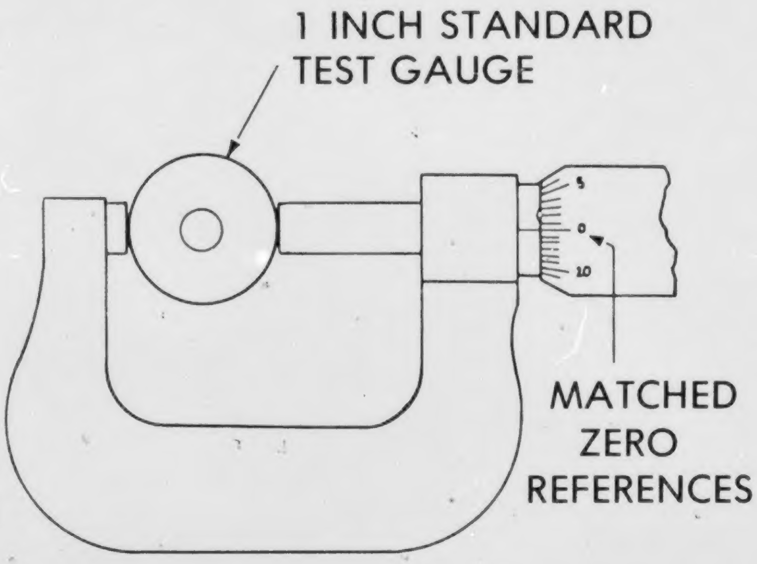
MICROMETER PARTS


SPINDLE
LOCK
SLEEVE
ANVIL
RATCHET STOP
THIMBLE
FRAME
0 - 1
0 1 2 3 4
5
SLEEVE
THIMBLE
40 THREADS PER INCH
SPINDLE AND SCREW

CHECKING THE MICROMETER FOR ACCURACY

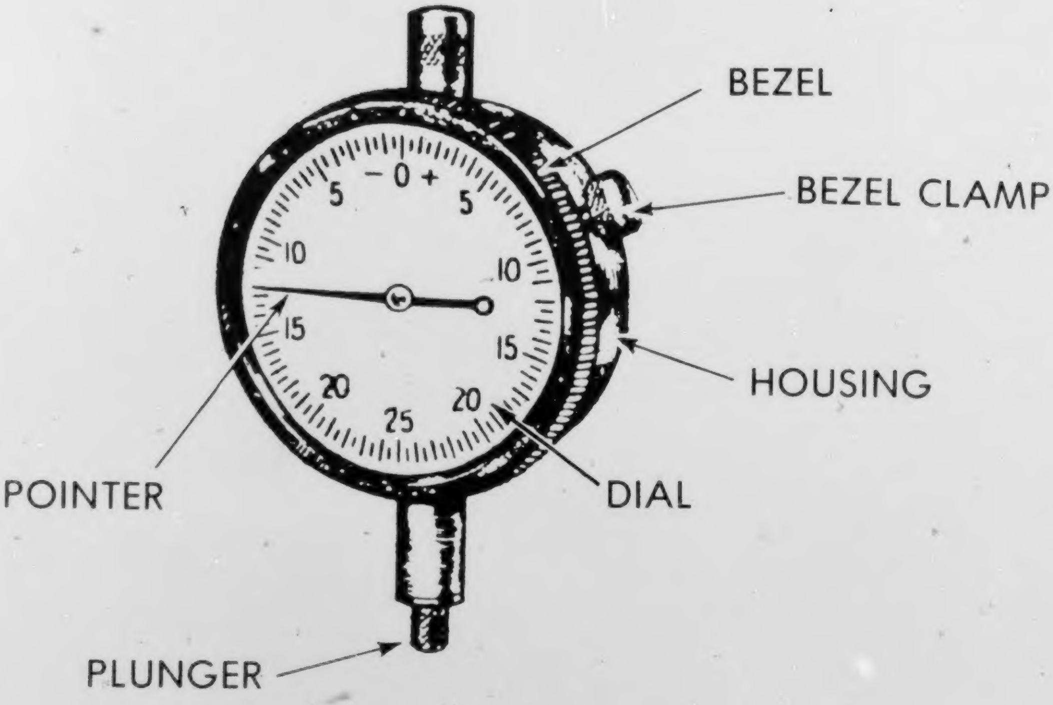

CLOSED
SLEEVE
THIMBLE
5
0
5
MATCHED
ZERO
REFERENCES

1 Inch Micrometer

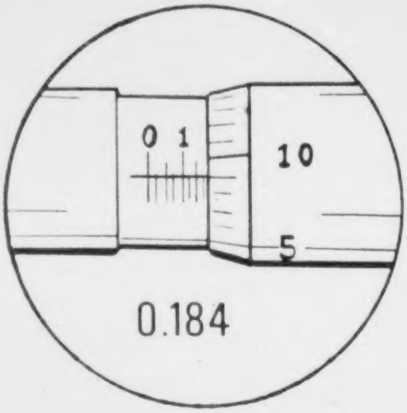

1 INCH STANDARD
TEST GAUGE
5
0
10
MATCHED
ZERO
REFERENCES

2 Inch Micrometer

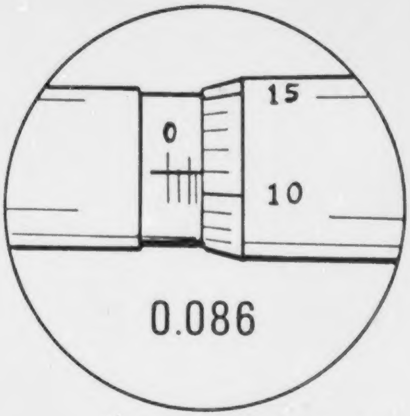
DIAL INDICATOR PARTS


BEZEL
BEZEL CLAMP
HOUSING
DIAL
POINTER
PLUNGER
5
– 0 +
5
10
10
15
15
20
20
25

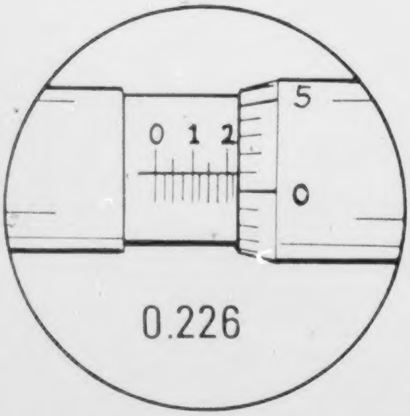
READING A MICROMETER



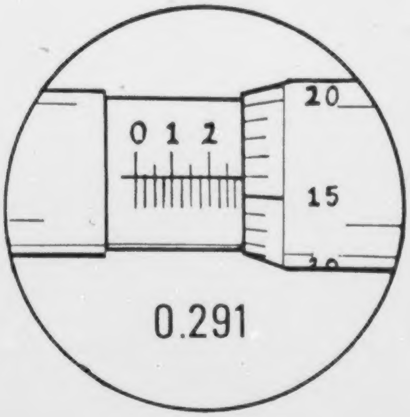
0.184



0.086

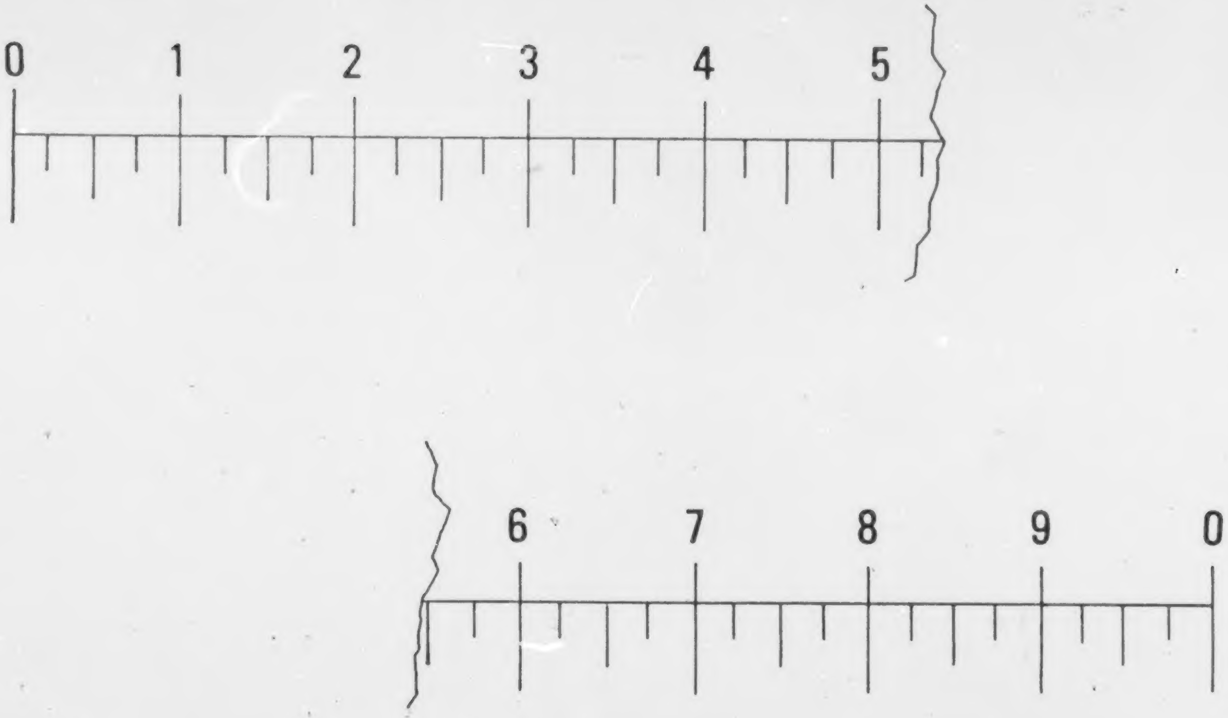


0.226

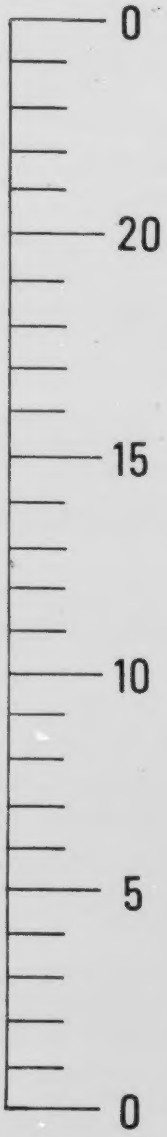


0.291

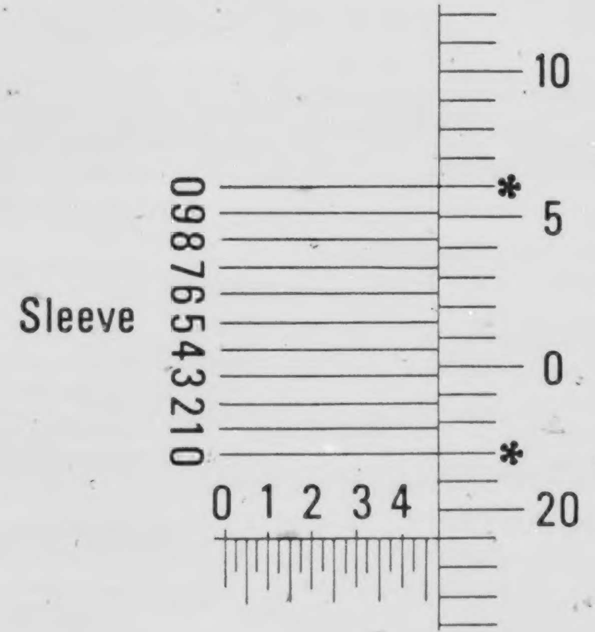
SLEEVE READINGS


0
1
2
3
4
5
6
7
8
9
0

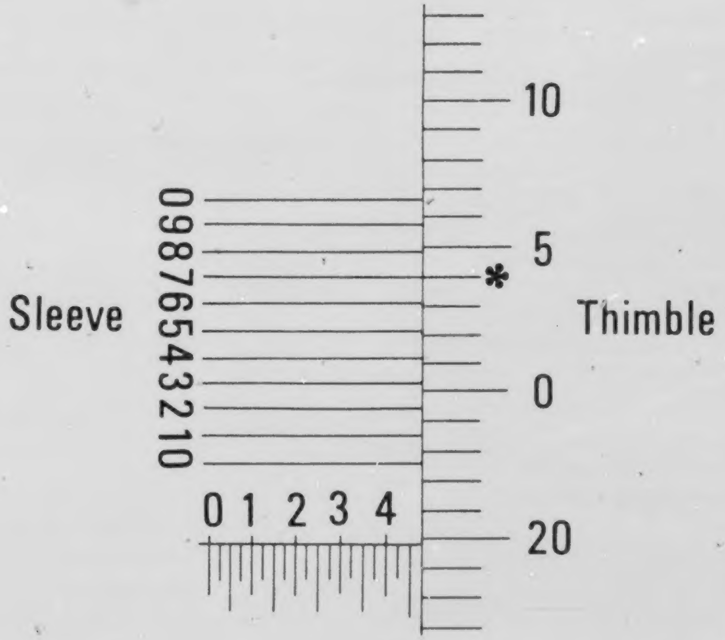
THIMBLE SLEEVE READINGS



VERNIER MICROMETER READINGS

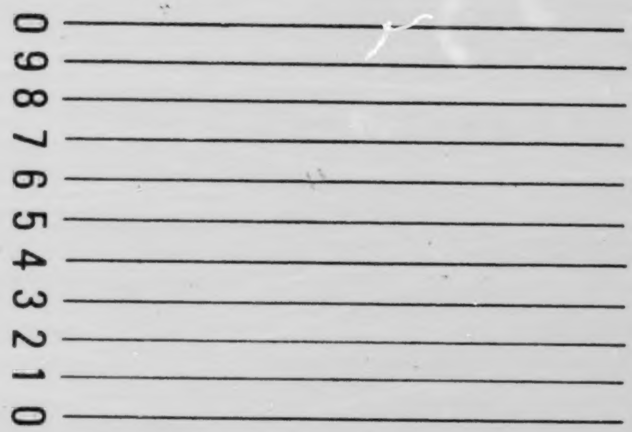

Sleeve
0987654321 0
0 1 2 3 4
Thimble
10
*
5
0
*
20

0.4690


Sleeve
0987654321 0
0 1 2 3 4
Thimble
10
5
*
0
20

0.4697

VERNIER SLEEVE READINGS


0
9
8
7
6
5
4
3
2
1
0

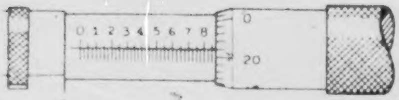
MEASURING
UNIT IV

ASSIGNMENT SHEET #1–READ THE PLAIN MICROMETER SETTINGS

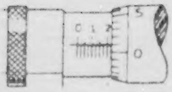
Read the plain micrometer settings below and write the correct answers in the blanks provided.

Answers

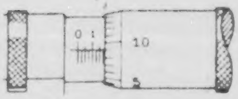
1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______
8. ______
9. ______
10. ______
11. ______
12. ______
13. ______
14. ______
15. ______
16. ______
17. ______
18. ______
19. ______
20. ______


0 1 2 3 4 5 6 7 8
0
20

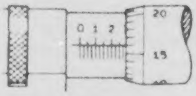
1.



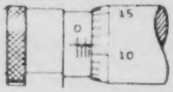
2.



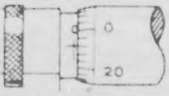
3.



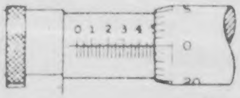
4.



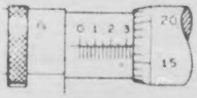
5.



6.


0 1 2 3 4 5
5
0
20

7.



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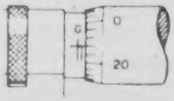

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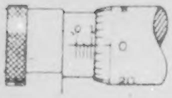
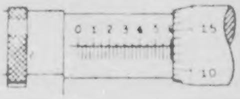
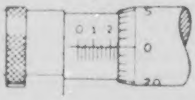


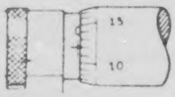
10.


0 1 2 3 4 5
15
10

11.



12.



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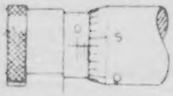
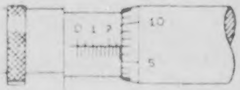
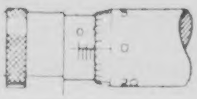


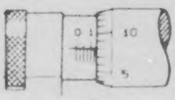
14.



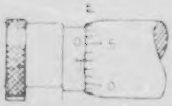
15.



16.



17.



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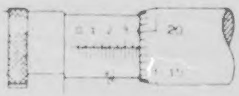

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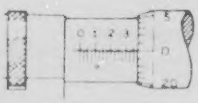


20.

ASSIGNMENT SHEET #1

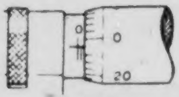
21. ______

22. ______

23. ______

24. ______

25. ______



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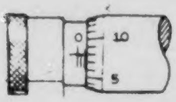

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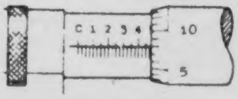

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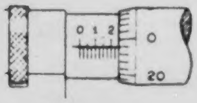

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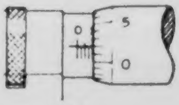


25.

MEASURING
UNIT IV

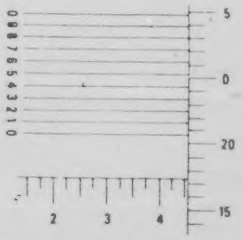
ASSIGNMENT SHEET #2–READ THE VERNIER MICROMETER SETTINGS

Read the vernier micrometer settings below, and write the correct answers in the blanks provided.

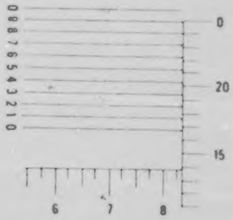
Answers

1. ____________
2. ____________
3. ____________
4. ____________
5. ____________
6. ____________
7. ____________
8. ____________
9. ____________
10. ____________

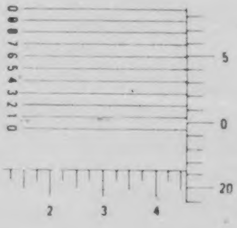
1.


0 9 8 7 6 5 4 3 2 1 0
5
0
20
15
2 3 4

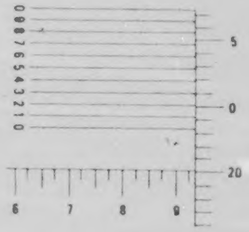
2.


0 9 8 7 6 5 4 3 2 1 0
0
20
15
6 7 8

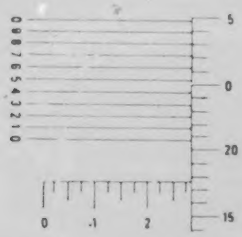
3.


0 9 8 7 6 5 4 3 2 1 0
5
0
20
2 3 4

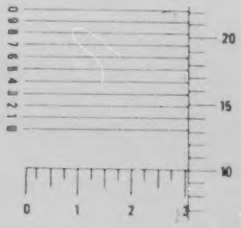
4.


0 9 8 7 6 5 4 3 2 1 0
5
0
20
6 7 8 9

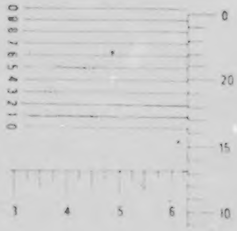
5.


0 9 8 7 6 5 4 3 2 1 0
5
0
20
15
0 1 2

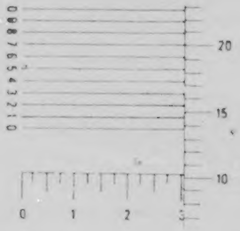
6.


0 9 8 7 6 5 4 3 2 1 0
20
15
10
0 1 2 3

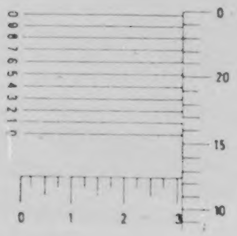
7.


0 9 8 7 6 5 4 3 2 1 0
0
20
15
10
3 4 5 6

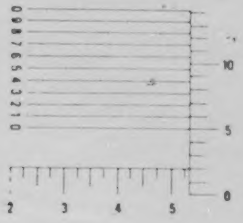
8.


0 9 8 7 6 5 4 3 2 1 0
20
15
10
0 1 2 3

9.


0 9 8 7 6 5 4 3 2 1 0
0
20
15
10
0 1 2 3

10.


0 9 8 7 6 5 4 3 2 1 0
10
5
0
2 3 4 5

MEASURING
UNIT IV

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. 0.871
2. 0.226
3. 0.184
4. 0.291
5. 0.086
6. 0.023
7. 0.500
8. 0.342
9. 0.047
10. 0.125
11. 0.613
12. 0.250
13. 0.012
14. 0.079
15. 0.282
16. 0.100
17. 0.133
18. 0.053
19. 0.393
20. 0.375

21. 0.049
22. 0.058
23. 0.483
24. 0.249
25. 0.102

Assignment Sheet #2

1. 0.4678
2. 0.8388
3. 0.4715
4. 0.9453
5. 0.2928
6. 0.3101
7. 0.6383
8. 0.3107
9. 0.3128
10. 0.5270

MEASURING
UNIT IV

JOB SHEET #1--USE A VERNIER CALIPER

I. Tools and materials

  A. Vernier caliper

  B. Workpieces

    1. Assortment of fractional drill bits

    2. Assortment of letter size drill bits

    3. Assortment of machined parts

    (NOTE: All work pieces should be numbered or lettered for reference.)

II. Procedure

  A. Select workpieces that are smooth and free of burrs, nicks, or dents

  B. Clean inside faces of caliper jaws

  C. Check vernier caliper at zero reference

  D. Open caliper greater than thickness of part to be measured

  E. Hook end jaw over part to be measured

  F. Slide movable jaw into contact with part

  G. Tighten clamp screw on fine adjustment nut

  H. Make fine adjustment with fine adjusting screw if necessary

  I. Tighten clamping screw above vernier plate

  J. Remove caliper from work carefully

  K. Read caliper

  L. List reading according to letter or number on workpiece

  M. Return vernier caliper to correct storage place

  N. Hand in the listed readings to instructor for evaluation

MEASURING
UNIT IV

JOB SHEET #2--USE A PLAIN MICROMETER

I. Tools and materials

A. Micrometers, plain

1. 0" - 1.000" size

2. 1.000" - 2.000" size

B. Lathe or vise

C. Workpieces

1. New fractional drill bits, assortment of 5

2. New letter size drill bits, assortment of 5

3. Pieces of metal such as cold rolled stock, machined parts, hardened dowels; assortment of 5

(NOTE: All workpieces should be numbered or lettered for reference.)

II. Procedure

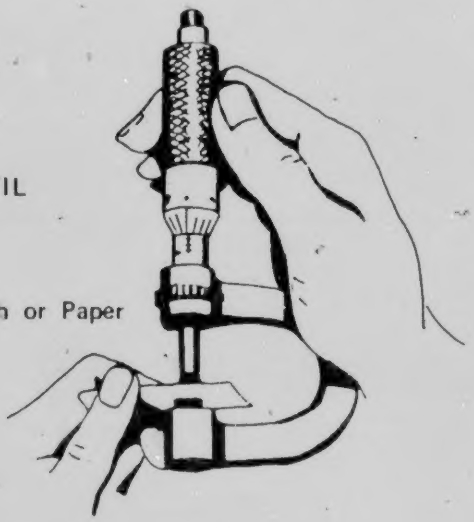
A. Select workpieces that are clean and free of burrs, nicks, or dents

B. Select the proper size micrometer for the workpiece

C. Clean the spindle and anvil of the micrometer (Figure 1)

FIGURE 1

CLEAN SPINDLE AND ANVIL



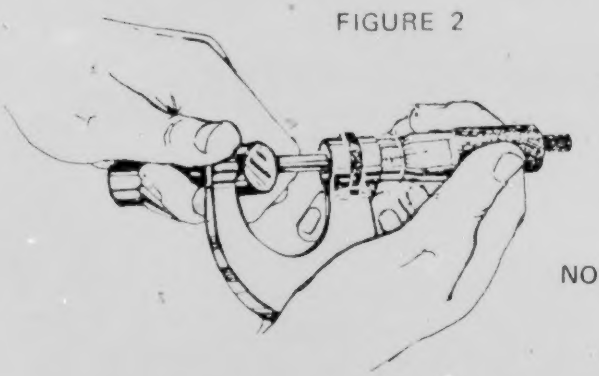
JOB SHEET #2

D. Check the micrometer at zero reference

E. Hold the micrometer according to the type of workpiece

1. Hold the micrometer in the right hand and the workpiece in the left hand to measure a nonstationary object (Figure 2)

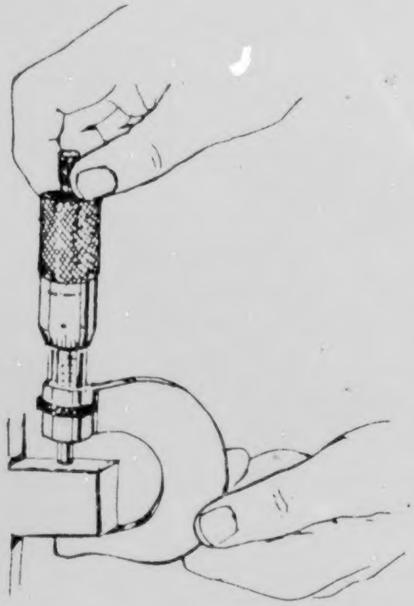
FIGURE 2



NONSTATIONARY OBJECT

2. Hold the micrometer in both hands to measure a stationary object (Figure 3)

FIGURE 3

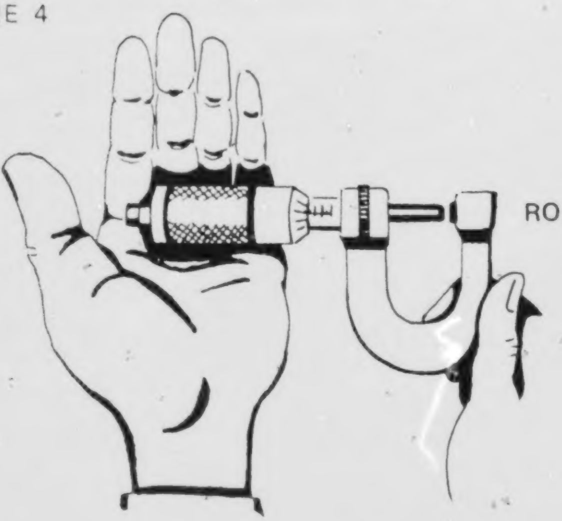


STATIONARY OBJECT

JOB SHEET #2

(NOTE: Roll micrometer along palm of hand or forearm for quick adjustment. See Figure 4.)

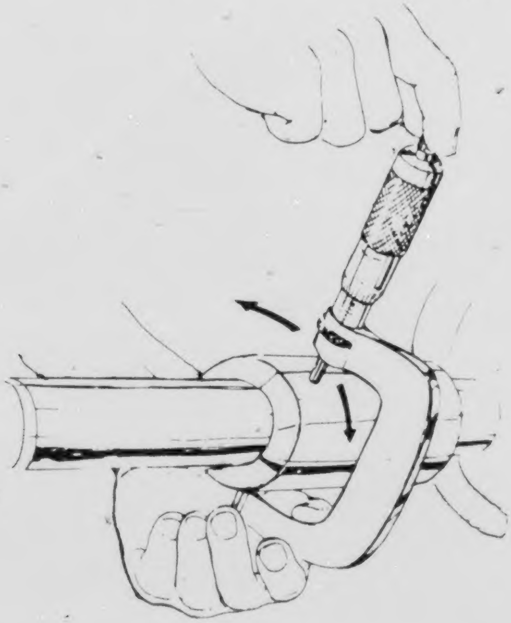
FIGURE 4



ROLL FOR QUICK ADJUSTMENT

F. Place the micrometer directly over the center of the workpiece to be measured (Figure 5)

FIGURE 5



WORK BACK AND FORTH TO FIND TRUE DIAMETER

JOB SHEET #2

G. Turn the thimble of the micrometer until the anvil and spindle contact the workpiece

H. Hold the anvil steady and move the spindle lightly over the workpiece to locate the true centerline

(NOTE: See Figure 5 on the preceding page.)

I. Use ratchet stop or light sense of feel to determine exact measurement

J. Observe micrometer readings

(NOTE: Spindle lock can be turned to hold measurement if micrometer must be removed from workpiece. Spindle must be unlocked before resetting to a new measurement.)

K. List the readings according to the letter or number on the workpiece

L. Return the micrometer to its correct storage

(NOTE: The spindle and anvil of the micrometer should be left open when stored.)

M. Hand in the listed readings to the instructor for evaluation

MEASURING
UNIT IV

JOB SHEET #3--USE A DIAL INDICATOR

I. Tools and materials

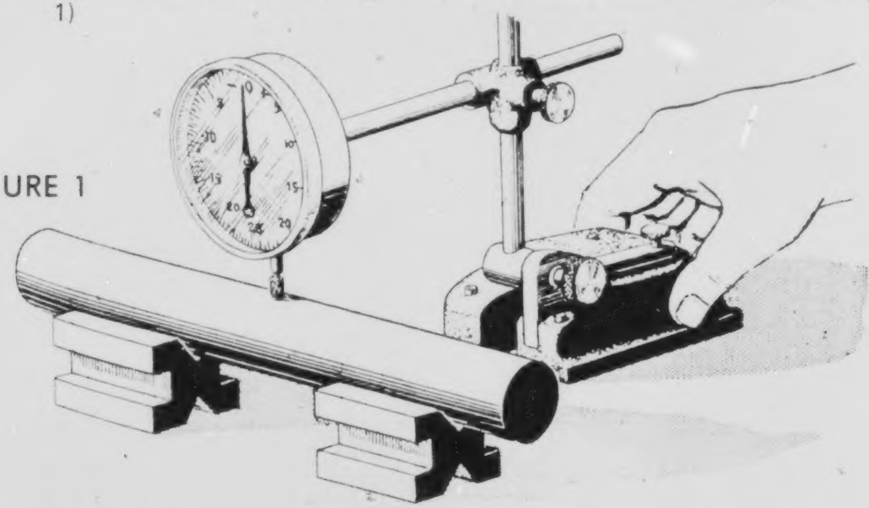
- A. Dial indicator
- B. Dial indicator holder
- C. Magnetic base
- D. V blocks - 2
- E. Appropriate assortment of machined parts

  (NOTE: All workpieces should be numbered or lettered for reference.)

II. Procedure

- A. Select workpieces that are clean and free of burrs, nicks, or dents
- B. Attach dial indicator to holder
- C. Secure holder to work surface
- D. Mount workpiece according to type of measurement to be made (Figure 1)

FIGURE 1



- E. Position holder so that dial indicator plunger contacts workpiece
- F. Adjust holder so that plunger is depressed two revolutions of pointer and tighten holder
- G. Rotate bezel until the zero marking is in line with pointer

JOB SHEET #3

H. Measure workpiece for taper, concentricity, and run-out

I. List readings according to the letter or number on the workpiece

J. Disassemble dial indicator and holder and return to the correct storage

K. Hand in the listed readings to the instructor for evaluation

MEASURING
UNIT IV

NAME ____________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Low precision measuring instrument graduated in fractional or decimal parts of an inch

_____b. Marking found on rules and scales to denote unit of length

_____c. Mistake in the reading or total measurement

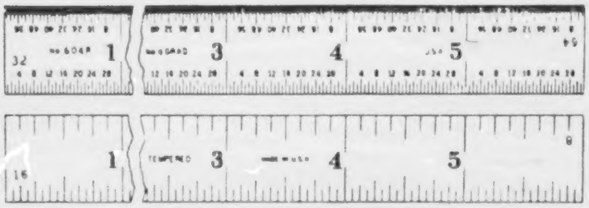
_____d. Accurate or true measurement

_____e. Starting point of measurement for both workpiece and rule

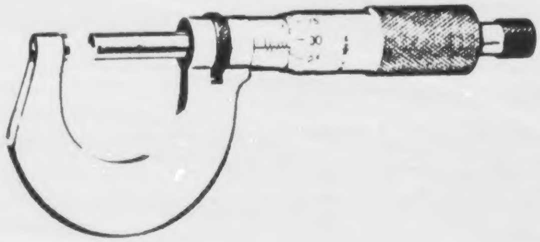
_____f. Makes accurate inside and outside measurements to within one-thousandth of an inch, or one-hundredth of a millimeter

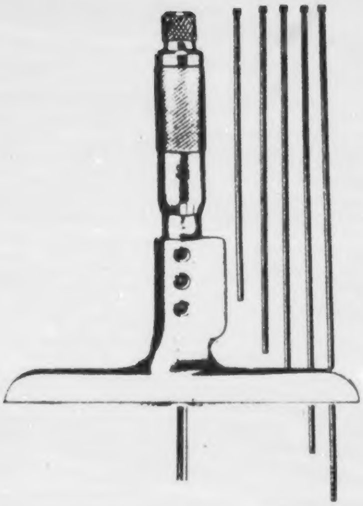
1. Graduation
2. Reliable measure
3. Vernier caliper
4. Steel rule
5. Reference point
6. Error

2. Identify measuring instruments used in small engine repair.

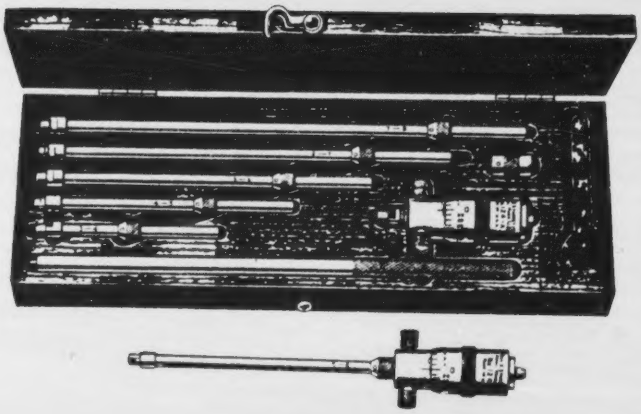


a. ____________________ b. ____________________

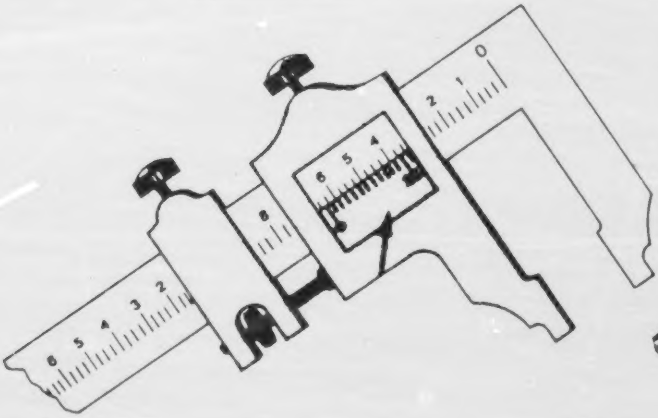




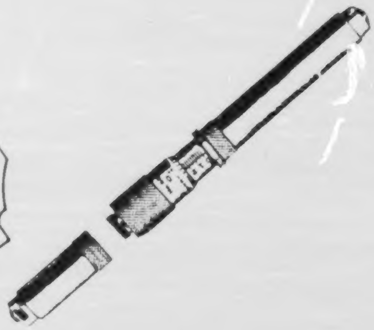
c. ______________________



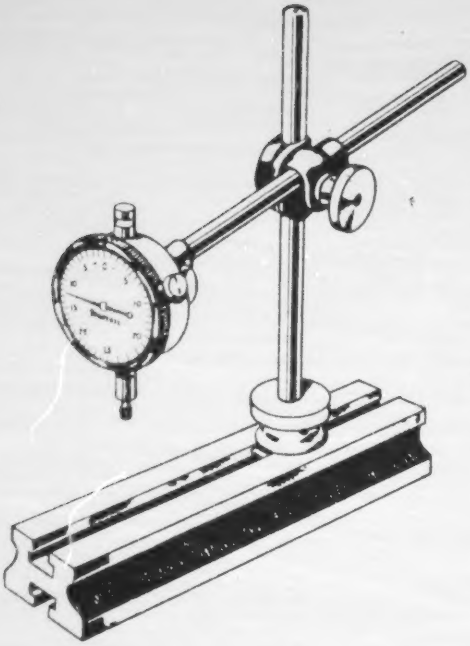
d. ______________________


0
1
2
4
5
6
8
2
3
4
5
6

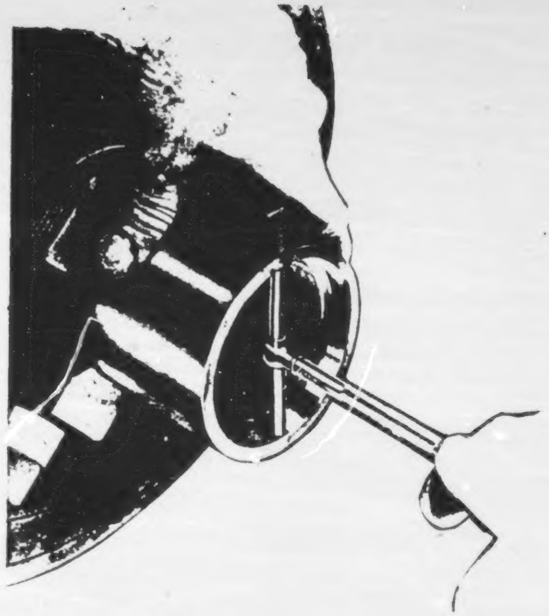
e. ______________________



f. ______________________



g. ____________________



h. ____________________

3. List four steps for reading measuring instruments.

   a.

   b.

   c.

   d.

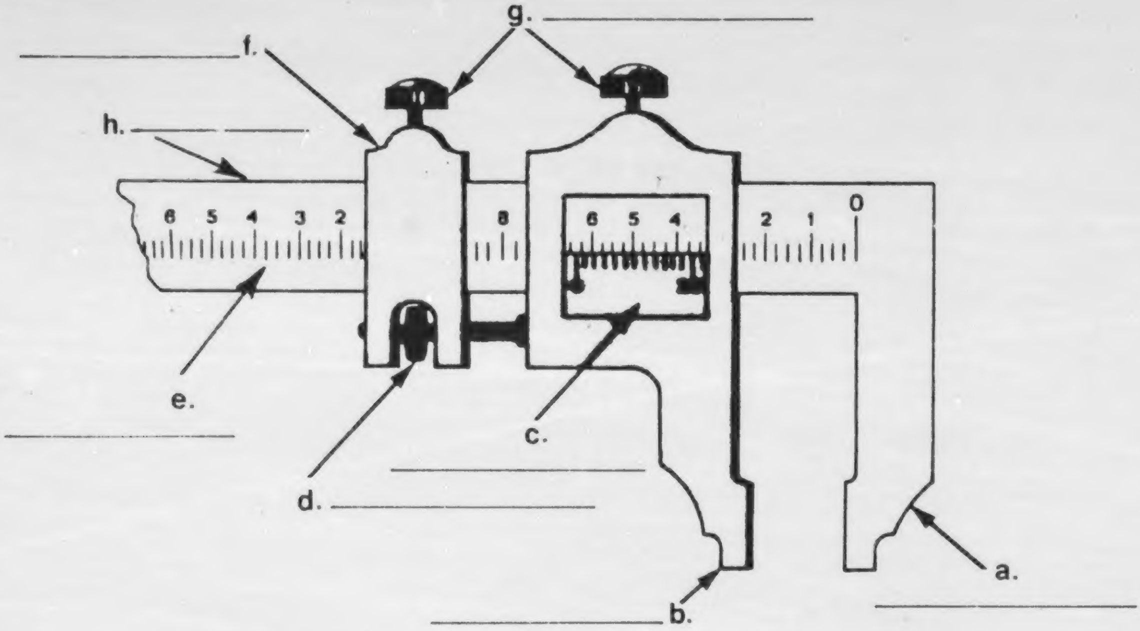
4. Name three basic units of measurement found on rules.

   a.

   b.

   c.

5. Identify the major parts of a vernier caliper.


g. ____________________
____________________ f.
h. ____________________
6
5
4
3
2
8
6
5
4
2
1
0
e.
____
c.
____
d. ____________________
a.
____________________ b.
____

6. Identify the major parts of an outside micrometer.

a. ____________________

b. ____________________

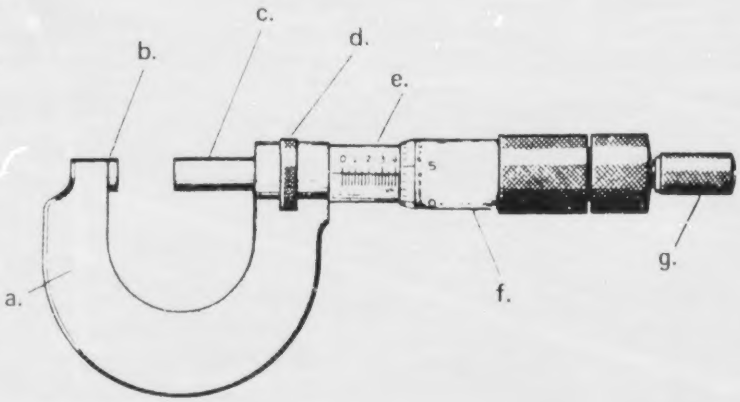
c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________



7. Discuss the proper methods for checking the accuracy of outside micrometers.

a. 0" - 1.000"

b. More than one inch

8. Identify the major parts of a dial indicator.

a. ____________________

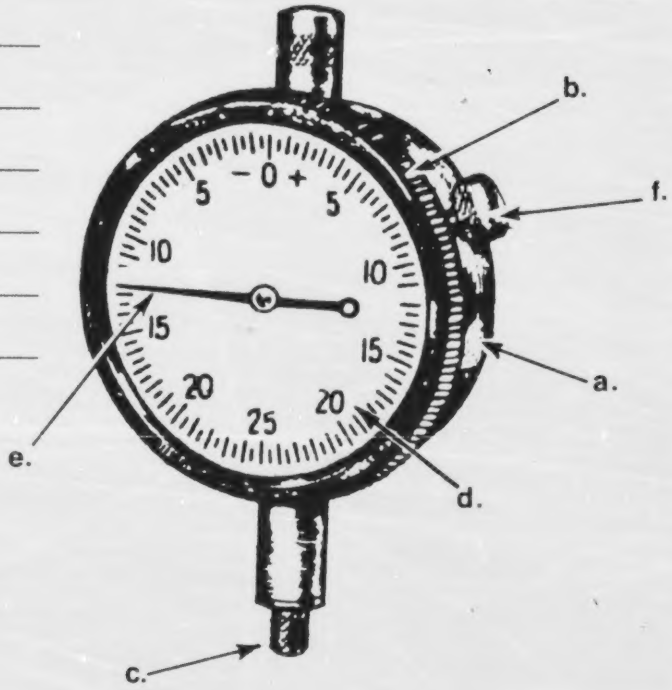
b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________



9. Arrange in order the steps for set up and use of a dial indicator by placing the correct sequence number in the appropriate blank.

______a. Pre-load dial indicator

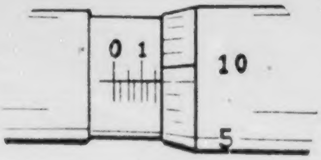
______b. Measure work

______c. Position plunger in contact with surface to be measured

______d. Secure dial indicator to suitable mounting fixture

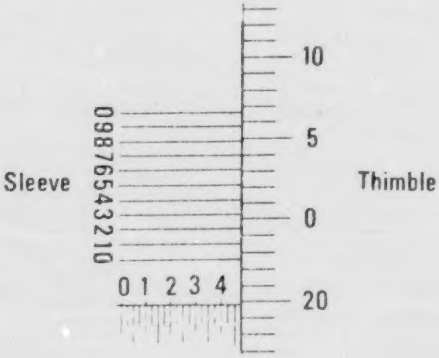
______e. Zero dial

10. Read the following plain micrometer settings.



Answer: ____________

11. Read the following vernier micrometer settings.


Sleeve
0987654321 0
0 1 2 3 4
Thimble
10
5
0
20

Answer: ____________

12. Demonstrate the ability to:

a. Use a vernier caliper.

b. Use a plain micrometer.

c. Use a dial indicator.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

MEASURING
UNIT IV

ANSWERS TO TEST

1. a. 4
   b. 1
   c. 6
   d. 2
   e. 5
   f. 3
2. a. Rule
   b. Outside micrometer
   c. Depth micrometer
   d. Inside micrometer
   e. Vernier caliper
   f. Hole gauge
   g. Dial indicator
   h. Telescoping gauge
3. a. Select scale of the required units
   b. Total the number of graduations
   c. Count whole units
   d. Reduce graduations to lowest terms
4. a. Fractional
   b. Decimal
   c. Metric
5. a. Fixed jaw
   b. Movable jaw
   c. Vernier scale

- d. Adjusting nut
- e. Main scale
- f. Clamp
- g. Clamp screws
- h. Beam

6.
- a. Frame
- b. Anvil
- c. Spindle
- d. Lock
- e. Sleeve
- f. Thimble
- g. Ratchet stop

7. Discussion should include:
- a. 0" - 1.000"
  - 1) Close spindle and anvil together
  - 2) Observe zero references on the sleeve and thimble
- b. More than one inch
  - 1) Use a standard bar or disc to check the minimum capacity
  - 2) Observe zero references on the sleeve and thimble

8.
- a. Housing
- b. Bezel
- c. Plunger
- d. Dial
- e. Pointer
- f. Bezel clamp

9.
- a. 3
- b. 5
- c. 2

d. 1

e. 4

10. 0.159

11. 0.4697

12. Performance skills evaluated to the satisfaction of the instructor.

ENGINE IDENTIFICATION AND INSPECTION
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to distinguish between characteristics of a four-cycle and a two-cycle engine and list types of information which may be found on an engine nameplate. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with engine identification and inspection to the correct definitions.
2. Distinguish between the characteristics of a four-stroke cycle engine and a two-stroke cycle engine.
3. List three types of information which may be found on the engine nameplate.
4. Select engine information which may be determined from the operator's instructions and/or inspection of the engine.
5. Identify the operating positions of the crankshaft.
6. Complete an engine information form.

ENGINE IDENTIFICATION AND INSPECTION
UNIT I

SUGGESTED ACTIVITIES

I. Instructor
  A. Provide student with objective sheet.
  B. Provide student with information and assignment sheets.
  C. Make transparencies.
  D. Discuss unit and specific objectives.
  E. Discuss information and assignment sheets.
  F. Discuss decoding of serial numbers.
  G. Demonstrate differences and types of engines.
  H. Print out location of information and nameplate.
  I. Show examples of different operating positions of the crankshaft.
  J. Have operator's instruction booklets for engines available for use by the class.
  K. Give test.

II. Student
  A. Read objective sheet.
  B. Study information sheet.
  C. Complete assignment sheet.
  D. Examine different types of engines.
  E. Locate information on nameplate.
  F. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:
  A. Objective sheet
  B. Information sheet

C. Transparency masters
   1. TM 1--Engine Type Identification
   2. TM 2--Nameplate Information
   3. TM 3--Operating Positions of Crankshafts

D. Assignment Sheet #1--Complete Engine Information Form

E. Test

F. Answers to test

II. References:

A. *Small Engines.* Volume I. Athens Georgia: American Association for Vocational Instructional Materials, 1971.

ENGINE IDENTIFICATION AND INSPECTION
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Combustion chamber--Area between the piston and cylinder head when the piston is at the top of its stroke

(NOTE: It is in this area where the compressed fuel mixture is ignited and burned.)

B. Crankcase--Housing for the crankshaft and other related internal parts

C. Cycle--Completion of a series of events to produce a power impulse

D. Exhaust port--Opening to the outside of the combustion chamber for the release of exhaust gases

E. Intake port--Opening into the combustion chamber for the intake of the fuel-air charge

(NOTE: This is also called the transfer port on some engines.)

F. Four-stroke cycle engine--Engine design which develops a power stroke every other revolution of the crankshaft

G. Two-stroke cycle engine--Engine design permitting a power stroke once for each revolution of the crankshaft

H. Nameplate--Information plate attached by the manufacturer giving their name, the engine make, model, serial number, and other information

II. Characteristics of four-stroke cycle and two-stroke cycle engines (Transparency 1)

A. Four-stroke cycle engine

1. Has an oil sump and possible oil filter
2. Exhaust muffler connects at the head of the engine cylinder
3. Carburetor will always be on or near the cylinder head
4. Compression resistance is felt every other revolution

INFORMATION SHEET

B. Two-stroke cycle engine

  1. Does not have an oil sump and oil filter
  2. Exhaust port is about midpoint on the cylinder
  3. Carburetor may be located at the base of the cylinder or on the bottom or side of the crankcase
  4. Compression resistance is felt every revolution

III. Information which may be found on the engine nameplate (Transparency 2)

A. Make of engine, or name of the manufacturer

B. Model number

(NOTE: This usually gives the horsepower and may give the type of crankcase, accessories, or modifications.)

C. Identification numbers

(NOTE: Manufacturers add different types of information including bore, stroke and horsepower.)

IV. Engine information which may be determined from the operator's instructions and/or inspection of the engine

A. General information

  1. Name of equipment manufacturer
  2. Address of equipment manufacturer

B. Operating position of the crankshaft (Transparency 3)

C. Engine cycle

D. Model and other numbers

E. Types of accessories and major units

F. Service and maintenance specifications

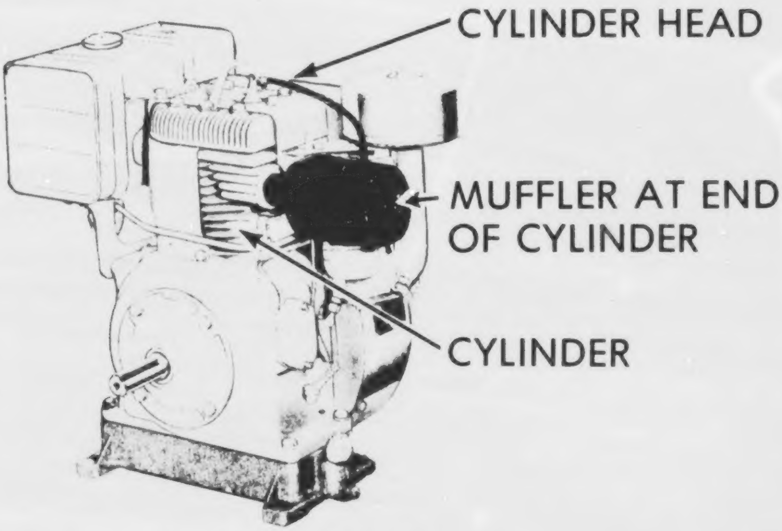
V. Operating positions of the crankshaft (Transparency 3)

A. Vertical

B. Horizontal

C. Multi-position

ENGINE TYPE IDENTIFICATION

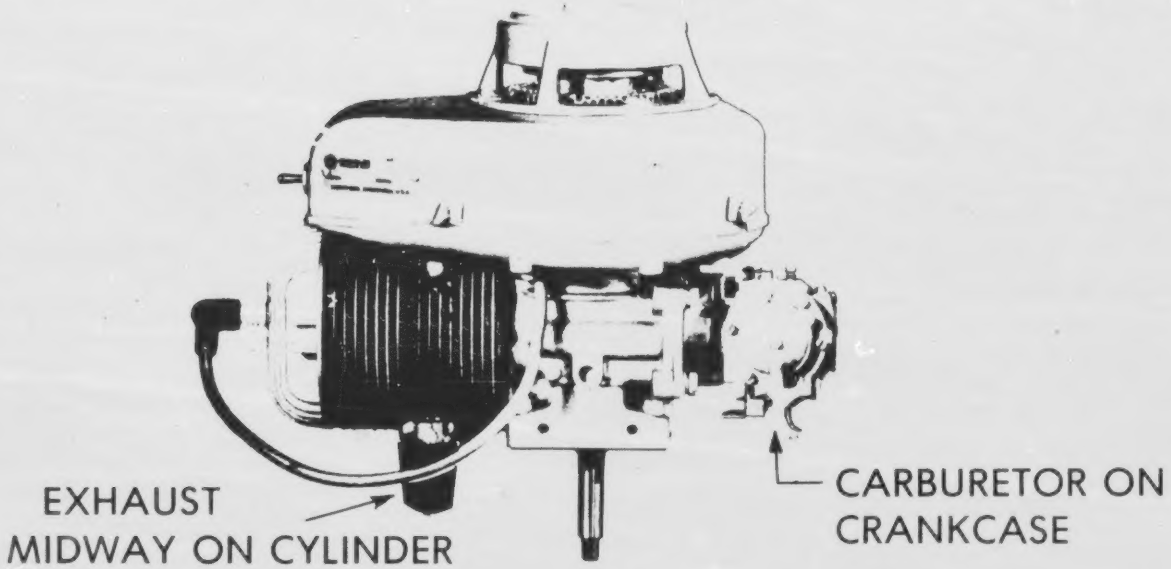

CYLINDER HEAD
MUFFLER AT END OF CYLINDER
CYLINDER

Four-Stroke Cycle

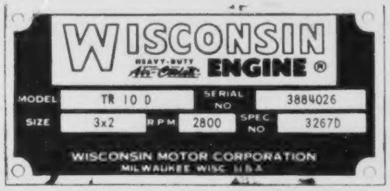
INTAKE AND EXHAUST BOTH AT TOP OF CYLINDER

Two-Stroke Cycle

INTAKE AND EXHAUST BOTH MIDWAY ON CYLINDER


EXHAUST MIDWAY ON CYLINDER
CARBURETOR ON CRANKCASE

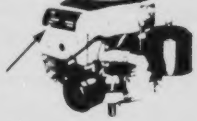
NAMEPLATE INFORMATION



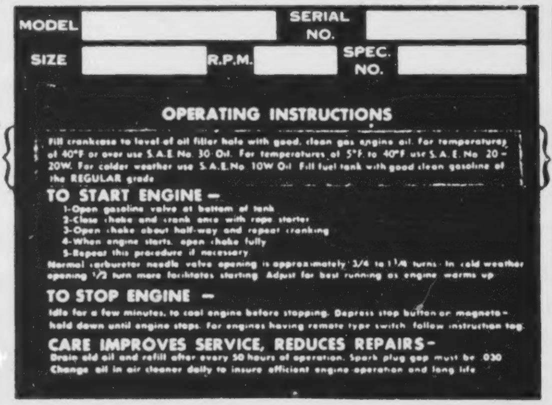
WISCONSIN
HEAVY-DUTY Air-Cooled ENGINE ®

MODEL	TR 10 D		SERIAL NO	3884026	
SIZE	3x2	R P M	2800	SPEC NO	3267D

WISCONSIN MOTOR CORPORATION
MILWAUKEE WISC. U.S.A.



NAME PLATE



MODEL			SERIAL NO.		
SIZE		R.P.M.		SPEC. NO.	

OPERATING INSTRUCTIONS

Fill crankcase to level of oil filler hole with good, clean gas engine oil. For temperatures of 40°F or over use S.A.E. No. 30 Oil. For temperatures of 5°F. to 40°F use S.A.E. No. 20-20W. For colder weather use S.A.E. No. 10W Oil. Fill fuel tank with good clean gasoline of the REGULAR grade

TO START ENGINE —

1-Open gasoline valve at bottom of tank
2-Close choke and crank once with rope starter
3-Open choke about half-way and repeat cranking
4-When engine starts, open choke fully
5-Repeat this procedure if necessary.

Normal carburetor needle valve opening is approximately 3/4 to 1 1/4 turns. In cold weather opening 1/2 turn more facilitates starting. Adjust for best running as engine warms up.

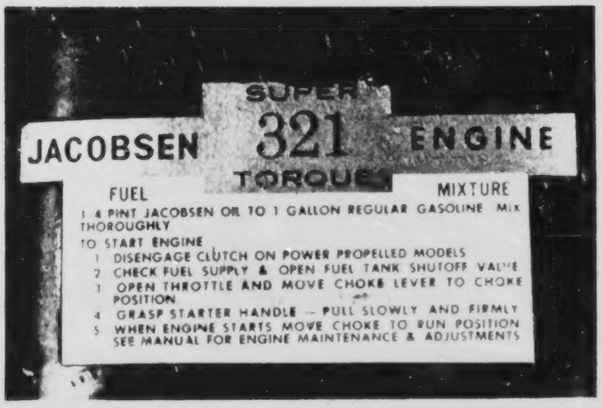
TO STOP ENGINE —

Idle for a few minutes, to cool engine before stopping. Depress stop button or magneto-hold down until engine stops. For engines having remote type switch, follow instruction tag.

CARE IMPROVES SERVICE, REDUCES REPAIRS-

Drain old oil and refill after every 50 hours of operation. Spark plug gap must be .030
Change oil in air cleaner daily to insure efficient engine operation and long life

FOUR-STROKE CYCLE ENGINE



JACOBSEN SUPER 321 TORQUE ENGINE

FUEL MIXTURE

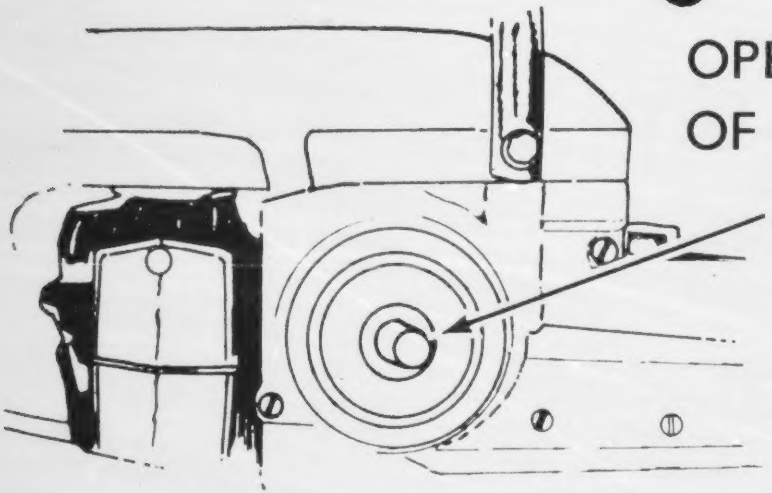
1 4 PINT JACOBSEN OIL TO 1 GALLON REGULAR GASOLINE MIX THOROUGHLY

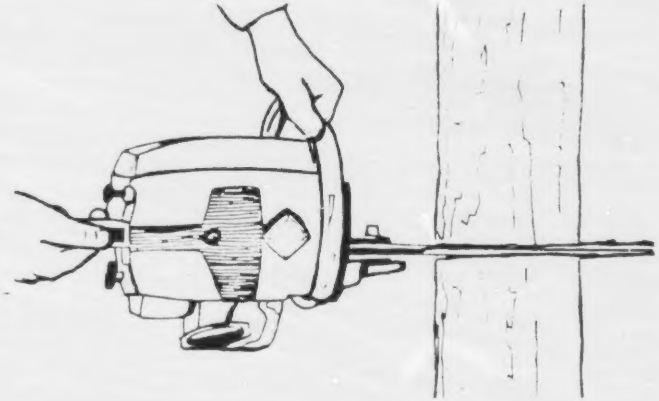
TO START ENGINE

1 DISENGAGE CLUTCH ON POWER PROPELLED MODELS
2 CHECK FUEL SUPPLY & OPEN FUEL TANK SHUTOFF VALVE
3 OPEN THROTTLE AND MOVE CHOKE LEVER TO CHOKE POSITION
4 GRASP STARTER HANDLE — PULL SLOWLY AND FIRMLY
5 WHEN ENGINE STARTS MOVE CHOKE TO RUN POSITION
SEE MANUAL FOR ENGINE MAINTENANCE & ADJUSTMENTS

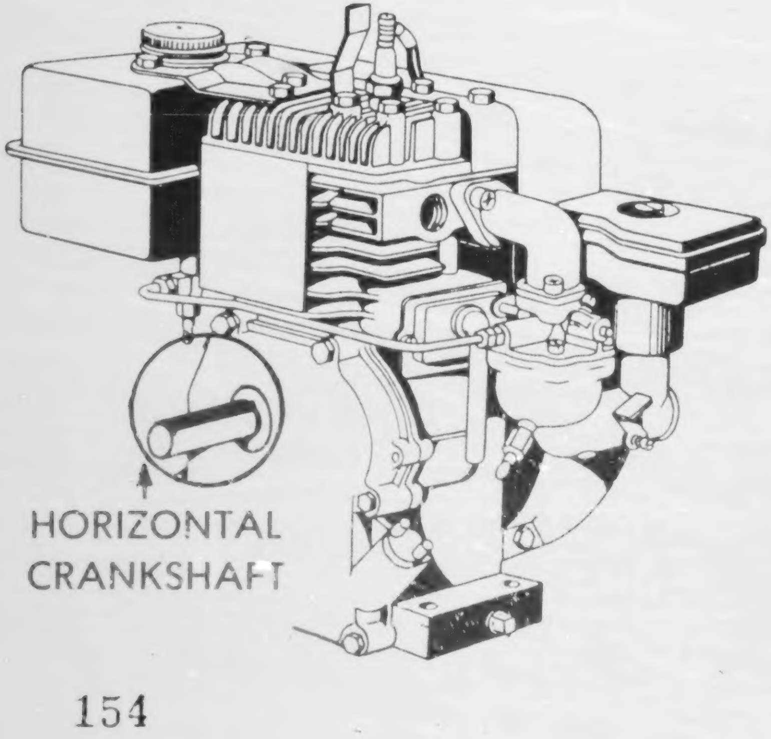
TWO-STROKE CYCLE ENGINE

OPERATING POSITIONS OF CRANKSHAFTS

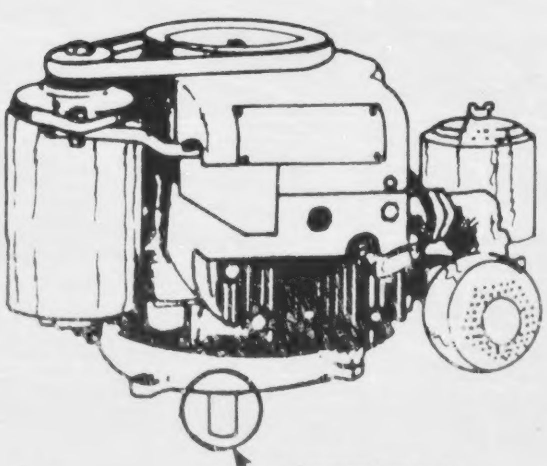




MULTI-POSITION CRANKSHAFT



HORIZONTAL CRANKSHAFT



VERTICAL CRANKSHAFT

ENGINE IDENTIFICATION AND INSPECTION
UNIT I

ASSIGNMENT SHEET #1--COMPLETE ENGINE INFORMATION FORM

Complete the following engine information form by looking at an engine and its operator's manual.

GENERAL INFORMATION: ______________________________

NAME OF EQUIPMENT (ON WHICH ENGINE IS MOUNTED) ______________

NAME AND ADDRESS OF EQUIPMENT MANUFACTURER ______________

____

NAME AND ADDRESS OF ENGINE MANUFACTURER ______________

____

OPERATING POSITION OF CRANKSHAFT: VERTICAL___, HORIZONTAL___, MULTI-POSITION___.

ENGINE CYCLE: 2-Cycle___, 4-cycle___.

MODEL NUMBER, OR NAME ______________________________

SERIAL NUMBER ______________________________

SPECIFICATION NUMBER ______________________________

TYPE NUMBER ______________________________

HORSEPOWER ______________________________

ASSIGNMENT SHEET #1

Types of accessories and major units:

Carburetor air cleaner: oil bath _____, oiled filter _____, dry filter _____.

Fuel strainer: combination screen and sediment bowl _____, screen inside the fuel tank _____.

Crankcase breather: reed valve _____, floating disc valve _____.

Starter: rope-wind _____, rope-rewind _____, wind up _____, electric, AC _____, electric, DC _____.

Ignition system: flywheel magneto _____, external magnet _____, battery _____.

Fuel pump: mechanically driven _____, differential pressure driven _____.

Carburetor: float _____, suction lift _____, diaphragm _____.

Governor: air vane _____, centrifugal _____.

Service and maintenance specifications:

Fuel: Octane number _____. Mixture of oil and gasoline (2 cycle) (Amount of oil per gallon of gasoline): 1/4 pint _____ 1/2 pint _____, other _____.

Oil: SAE grade: 5 W _____, SAE 10 W _____, SAE 20 W _____, SAE 30 _____, SAE 10 W-30 _____, Classification: ML _____, MM _____, MS _____, SC _____, SD _____.

Type of spark plug: _____ Gap setting .020", .025", other _____.

Ignition breaker-point gap: .012" _____, .015" _____, other _____

ENGINE IDENTIFICATION AND INSPECTION
UNIT I

NAME ______________________

TEST

1. Match the terms on the right to the correct definitions.

______ a. Area between the piston and cylinder head when the piston is at the top of its stroke

______ b. Information plate attached by the manufacturer giving their name, the engine make, model, serial number, and other information

______ c. Opening into the combustion chamber for the intake of the fuel-air charge

______ d. Engine design which develops a power stroke every other revolution of the crankshaft

______ e. Completion of a series of events to produce a power impulse

______ f. Opening to the outside of the combustion chamber for the release of exhaust gases

______ g. Engine design permitting a power stroke once for each revolution of the crankshaft

______ h. Housing for the crankshaft and other related internal parts

1. Nameplate
2. Exhaust port
3. Combustion chamber
4. Crankcase
5. Two-stroke cycle engine
6. Intake port
7. Four-stroke cycle engine
8. Cycle

2. Distinguish between the characteristics of a four-stroke cycle engine and a two-stroke cycle engine by placing an "X" next to the characteristics of a four-stroke cycle engine.

______ a. Carburetor will always be on or near the cylinder head

______ b. Has an oil sump and possible oil filter

______ c. Compression resistance is felt every other revolution

______ d. Exhaust port is about midpoint on the cylinder ______e. Compression resistance is felt every revolution

______f. Does not have an oil sump and oil filter

______g. Carburetor will always be on or near the cylinder head

3. List three types of information which may be found on the engine nameplate.

a.

b.

c.

4. Select engine information which may be determined from the operator's instructions and/or inspection of the engine by placing an "X" in the appropriate blanks.

______a. Engine cycle

______b. Model and other numbers

______c. Service and maintenance specifications

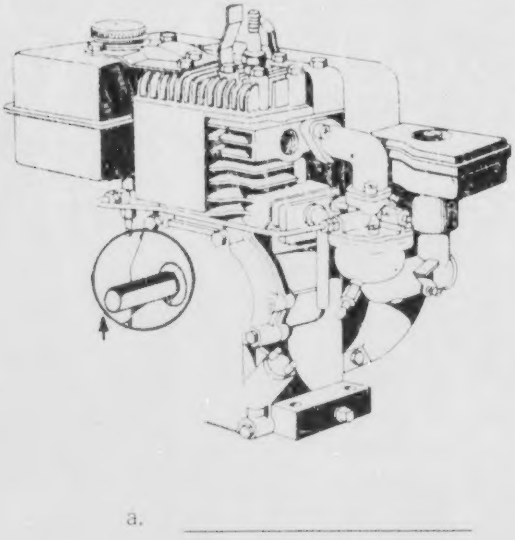
______d. Paint specifications on engine block

______e. Diameter of wire on high tension leads

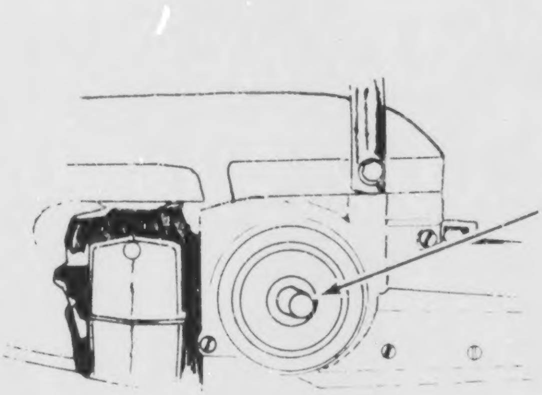
______f. Operating position of the crankshaft

______g. Breaker point weight

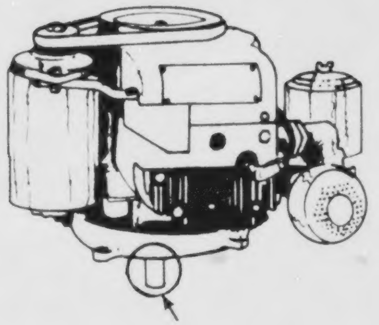
5. Identify the operating positions of the following crankshafts.



a. ______________________



b. ______________________



c. ______________________

6. Complete an engine information form.

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

ENGINE IDENTIFICATION AND INSPECTION
UNIT I

ANSWERS TO TEST

1. a. 3
   b. 1
   c. 6
   d. 7
   e. 8
   f. 2
   g. 5
   h. 4
2. a, b, c, g
3. a. Make of engine, or name of the manufacturer
   b. Model number
   c. Identification numbers
4. a, b, c, f
5. a. Horizontal
   b. Multi-position
   c. Vertical
6. Evaluated to the satisfaction of the instructor

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to list the characteristics, types, and forms of energy and calculate problems dealing with work, horsepower, torque, and cubic inch displacement. The student should also be able to distinguish between internal and external combustion engines and describe the operation of two-stroke and four-stroke cycle engines. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with basic engine principles to the correct definitions.
2. Discuss characteristics of energy.
3. List six types of energy.
4. List two forms of available energy.
5. List three types of motion.
6. Identify types of simple machines.
7. List three uses of simple machines.
8. Calculate problems using the formula for work.
9. Calculate problems using the formula for horsepower.
10. Calculate problems using the formula for torque.
11. State the main theoretical concept of heat engines.
12. Distinguish between types of heat engines.
13. Match the parts of a basic internal combustion engine to the correct descriptions.
14. Describe the process by which an internal combustion engine converts chemical energy into rotary motion.

15. Calculate problems using the formula for engine cubic inch displacement.
16. Calculate problems using the formula for compression ratio.
17. Discuss the purposes of a flywheel.
18. Identify types of engine design.
19. Identify types of engine cooling.

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Check with the major small engine manufacturers for visual aids to demonstrate basic engine principles.

   E. Discuss unit and specific objectives.

   F. Discuss information and assignment sheets.

   G. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Types of Motion

      2. TM 2--The Principle of the Lever

      3. TM 3--The Principle of the Wheel and Axle

4. TM 4--The Principle of the Pulley
5. TM 5--The Principle of the Inclined Plane
6. TM 6--The Principle of the Screw
7. TM 7--The Principle of the Wedge
8. TM 8--Basic Internal Combustion Engine Parts
9. TM 9--Chemical Energy to Rotary Motion
10. TM 10--Cubic Inch Displacement
11. TM 11--Compression Ratio-6 to 1
12. TM 12--Engine Designs
13. TM 13--Engine Designs (Continued)
14. TM 14--Engine Cooling Systems

D. Assignment sheets

1. Assignment Sheet #1--Calculate Work
2. Assignment Sheet #2--Calculate Horsepower
3. Assignment Sheet #3--Calculate Torque
4. Assignment Sheet #4--Calculate Cubic Inch Displacement
5. Assignment Sheet #5--Calculate Compression Ratio

E. Answers to assignment sheets

F. Test

G. Answers to test

II. References:

A. Bohn; Ralph C., and MacDonald, Angus J. *Power: Mechanics of Energy Control*. Bloomington, Illinois: McKnight and McKnight, 1970.

B. Stockel, Martin W. *Auto Mechanics Fundamentals*. South Holland, Illinois: Goodheart-Willcox Co., 1969.

C. *A Power Primer*. Detroit, Michigan: General Motors, 1955.

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Force–Any agent that produces or tends to produce motion

B. Work–Results of force overcoming a resistance over a definite distance

C. Energy–Ability to do work

D. Potential energy–Stored energy

E. Kinetic energy–Energy in motion

F. Power–Rate at which work is done

G. Horsepower–Measurement of work accomplished in a given period of time

(NOTE: One horsepower is a unit of power equal to 746 watts.)

H. Torque–Measurement of turning effort

I. Friction–Resistance to relative motion between two bodies in contact

J. PSI–Pounds per square inch; most common unit for measuring pressure

(NOTE: The metric equivalent to psi is kilogram per square centimeter, kg/cm^2.)

K. Mechanical power–Transmission and control of motion through the use of gears, pulleys, shafts, and other mechanical devices

L. Reciprocating motion–Back and forth motion

M. Cycle–Series of events or operations that happen regularly and lead back to the starting point

N. Control–To exercise restraining or directing influence over working forces

O. Transmission–Relaying of a working force

P. TDC–Top dead center

(NOTE: TDC may also be stated as ATDC, after top dead center, or BTDC, before top dead center.)

INFORMATION SHEET

Q. BDC-Bottom dead center

(NOTE: BDC may also be stated as ABDC, after bottom dead center, or BBDC, before bottom dead center.)

R. Stroke-Distance the piston moves when traveling from TDC to BDC

S. Bore-Diameter of the cylinder

T. Displacement-Total volume of air-fuel compressed by the piston in traveling from BDC to TDC

U. CID-Cubic inch displacement

(NOTE: Metric measurement for displacement is in cubic centimeters or liters.)

V. Combustion-Action or operation of burning

II. Characteristics of energy

A. Energy is ever present

B. Energy cannot be created or destroyed

C. Energy can only be changed from one kind to another

III. Types of energy

A. Light

(NOTE: Light energy promotes growth in plants and makes our surroundings visible.)

B. Heat

(NOTE: Heat energy cooks food, develops mechanical energy to power automobiles, and warms homes.)

C. Chemical

(NOTE: Chemical energy is the energy of life.)

D. Electrical

(NOTE: Electrical energy is the most flexible and is best known for lighting lights, running motors, and providing communications.)

E. Nuclear

(NOTE: Nuclear energy, also known as atomic energy, is produced through rearrangement of atoms.)

INFORMATION SHEET

F. Mechanical

(NOTE: Mechanical energy is contained in every moving object; it is the energy involved in motion.)

IV. Forms of available energy

A. Potential

(NOTE: Potential energy is stored energy.)

Examples: Fuel, stretched spring

B. Kinetic

(NOTE: Kinetic energy is energy in motion.)

Examples: Gasoline burning, wind, flowing water

V. Types of motion (Transparency 1)

A. Reciprocating

B. Rotary

C. Linear

VI. Simple machines

(NOTE: All of the complicated mechanisms used in the operation, manufacture, and repair of a small engine are combinations of six simple machines.)

A. Lever (Transparency 2)

B. Wheel and axle (Transparency 3)

C. Pulley (Transparency 4)

D. Inclined plane (Transparency 5)

E. Screw (Transp: ency 6)

F. Wedge (Transparency 7)

VII. Uses of simple machines

A. Increase force

B. Change direction

C. Change speed

INFORMATION SHEET

VIII. Formula for work Work = Force × Distance

(NOTE: Force must be used to measure work for all movement except lifting. Work is measured in foot pounds.)

Example: How much work is accomplished if it takes 80 pounds of force to move a 300 pound box 50 feet?

$W = F \times D$
$W = 80 \times 50$
$W = 4000$ foot pounds

IX. Formula for horsepower Horsepower $= \dfrac{\text{Force} \times \text{distance}}{\text{Time (sec)} \times 550}$ or

$\dfrac{\text{Weight} \times \text{distance}}{\text{Time (sec)} \times 550}$

(NOTE: One horsepower is 550 foot pounds of work done in one second. Force must be used instead of weight in all situations except lifting.)

Example: A 180 pound man climbs a 10 foot flight of stairs in 5 seconds. How much horsepower does he develop?

$$HP = \frac{W \times D}{\text{Time (sec)} \times 550}$$
$$HP = \frac{180 \times 10}{5 \times 550}$$
$$HP = \frac{1800}{2750}$$
$$HP = .65 \text{ horsepower}$$

X. Formula for torque Torque = Force × Radius

(NOTE: Unit of measurement is pound feet measured as a force applied to a radius.)

Example: If 25 pounds of force is applied to a wrench 2 feet long, what is the torque?

$T = F \times R$
$T = 25 \times 2$
$T = 50$ pound feet

XI. Main theoretical concept of heat engines: Converts heat energy into usable power in the form of motion

INFORMATION SHEET

XII. Types of heat engines

A. External combustion- Fuel produces heat energy outside the engine and is transmitted to the engine by water or other means to power the engine which converts heat energy to motion

B. Internal combustion- Fuel is burned inside the engine to produce heat energy which the engine converts to motion

Examples: Gasoline, diesel

XIII. Parts of basic internal combustion engine (Transparency 8)

A. Cylinder- Hollow tube closed at one end by the cylinder head

B. Piston- Cylindrical object which slides in the tube, fitting tightly to seal other end of tube

C. Rings- Circular devices fitted to the upper end of the piston which seal the piston to the cylinder to control loss of compression and lubricating oil

D. Connecting rod- Straight rod with one end connected to a pivot in the piston so lower end can swing with the rotation of the crankshaft

E. Crankshaft- Main shaft of an engine which, in conjunction with connecting rods, changes reciprocating motion of pistons into rotary motion

(NOTE: The lower end of the connecting rod is connected to offset center portion of crankshaft and must follow the same circular path as shaft.)

F. Valve- Movable plug to open and close the cylinder in order to let in air fuel mixture and to remove the burned fuel from the cylinder

G. Port- Passage behind the valves which conducts fuel and air into and exhaust out of the cylinder

XIV. Process by which an internal combustion engine converts chemical energy into rotary motion (Transparency 9)

A. Gasoline and air are introduced into the upper end of the cylinder

B. Air fuel mixture is ignited and burned, producing heat energy

INFORMATION SHEET

C. Heat energy causes the cylinder gases to expand

D. Expansion of the burning gases pushes piston down the cylinder

E. Downward motion of piston transmits force to the crankshaft through the connecting rod to produce rotary motion

(NOTE: Rotary motion is a result of the turning crankshaft.)

XV. Formula for cubic inch displacement (Transparency 10)

Cubic inch displacement = $\frac{\pi \times \text{Bore}^2 \times \text{Stroke}}{4} \times \text{Number of cylinders}$

Example: An 8 cylinder engine with a 4" bore and 3 1/2" stroke has how much displacement?

CID = $\frac{(3.1416) \times \text{Bore}^2\ (4^2) \times \text{Stroke}\ (3.50)}{4} \times$ No. of cylinders (8)

CID = $\frac{3.1416 \times 4^2 \times 3.5}{4} \times 8$

CID = 43.98×8

CID = 351.85 cubic inch displacement

(NOTE: One liter is equal fo 61.02 cubic inches.)

XVI. Formula for compression ratio: Air volume of cylinder with the piston at BDC divided by volume with piston at TDC (Transparency 11)

Example: Cylinder volume at BDC is 42.35 cu. in. Volume at TDC is 4.45 cu. in. Compression ratio is 9.5 to 1 [42.35 ÷ 4.5 = 9.5 : 1]

XVII. Purposes of a flywheel

A. Smooth out surges of the power strokes

B. Maintain crankshaft motion between power strokes

C. Develop kinetic energy when spinning

D. Provide gear teeth on outer rim for starting motor operation

INFORMATION SHEET

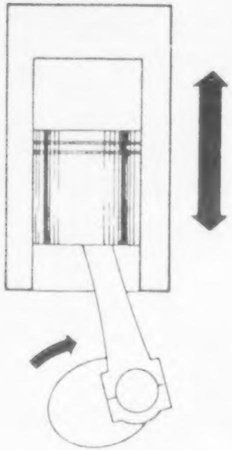
XVIII. Types of engine design (Transparencies 12 and 13)

- A. In-line
- B. V-type
- C. Opposed
- D. Radial
- E. Rotary

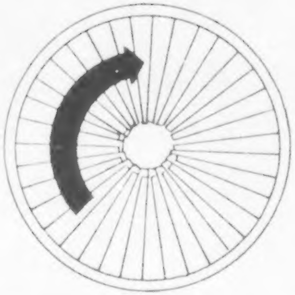
XIX. Types of engine cooling systems (Transparency 14)

- A. Liquid
- B. Air

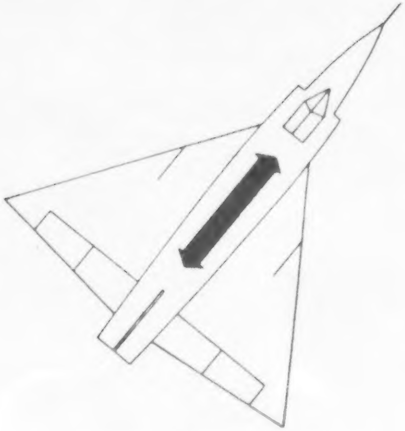
TYPES OF MOTION



Reciprocating Input Motion
From a Piston

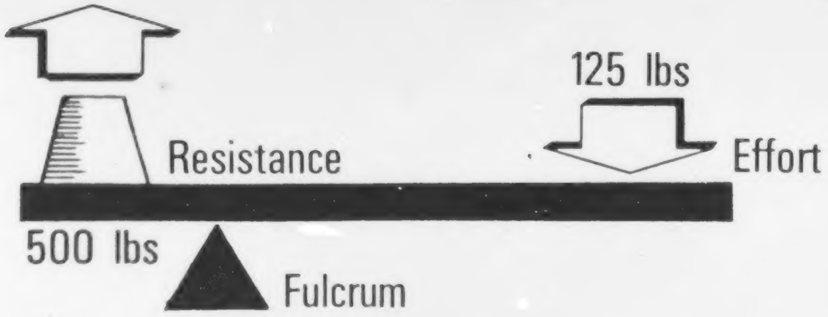


Rotary Input Motion
from a Turbine

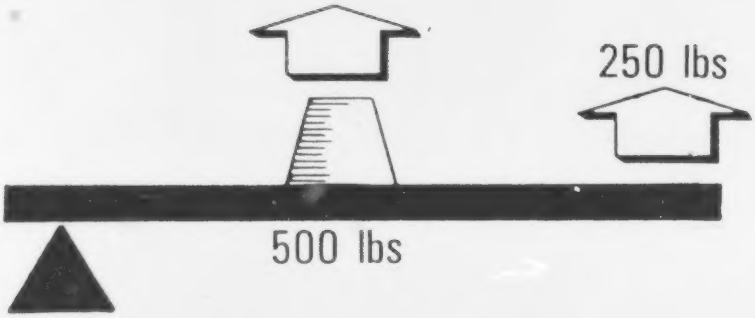


Linear Input Motion
from a Jet

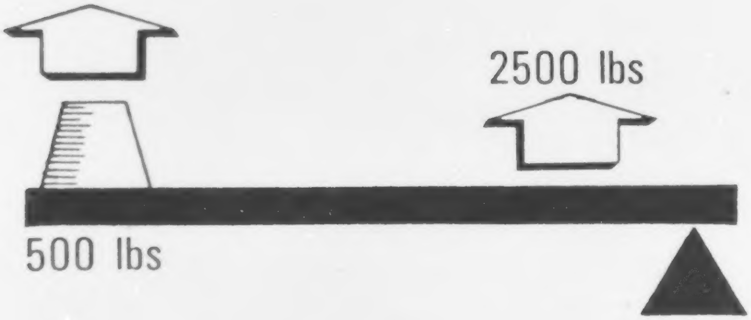
THE PRINCIPLE OF THE LEVER


125 lbs
Resistance
Effort
500 lbs
Fulcrum

First Class

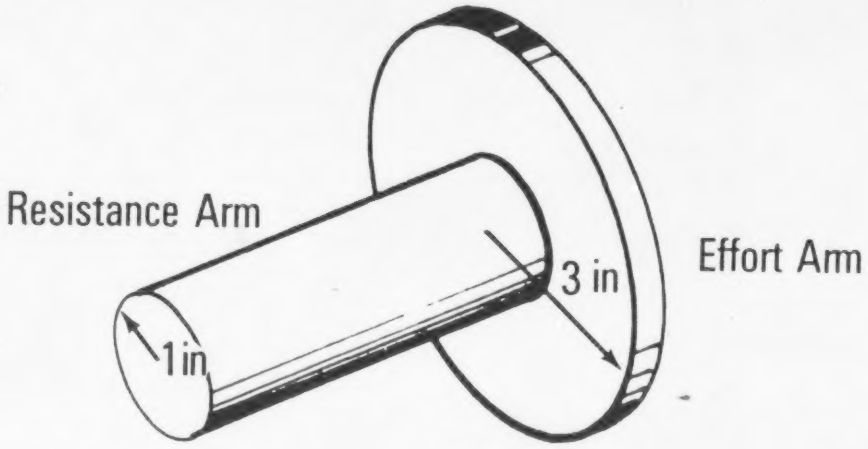

250 lbs
500 lbs

Second Class


2500 lbs
500 lbs

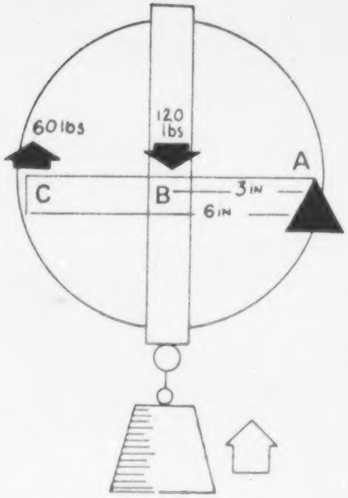
Third Class

THE PRINCIPLE OF THE WHEEL AND AXLE

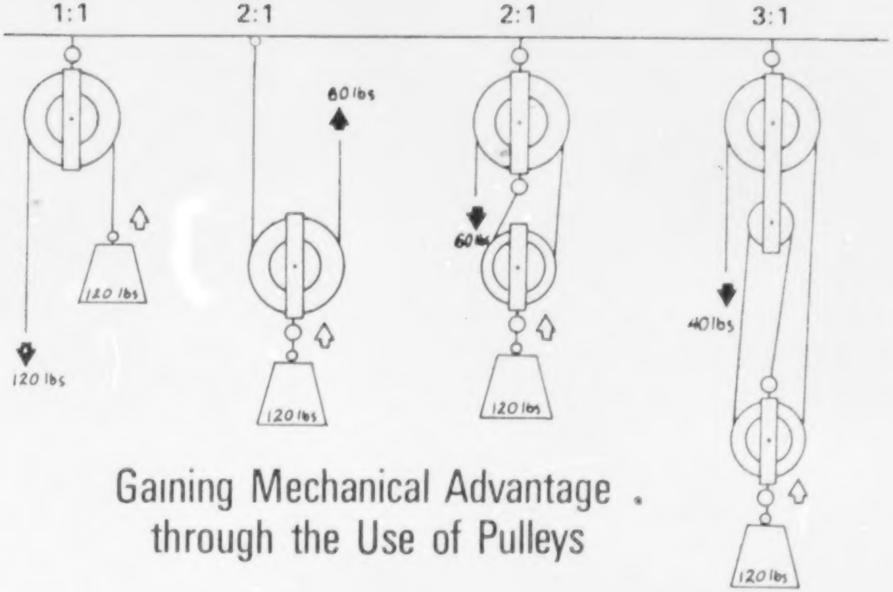

Resistance Arm
3 in
Effort Arm
1 in

The Mechanical Advantage of the Wheel and Axle is the Ratio between the Two Lever Arms, 3 to 1

THE PRINCIPLE OF THE PULLEY

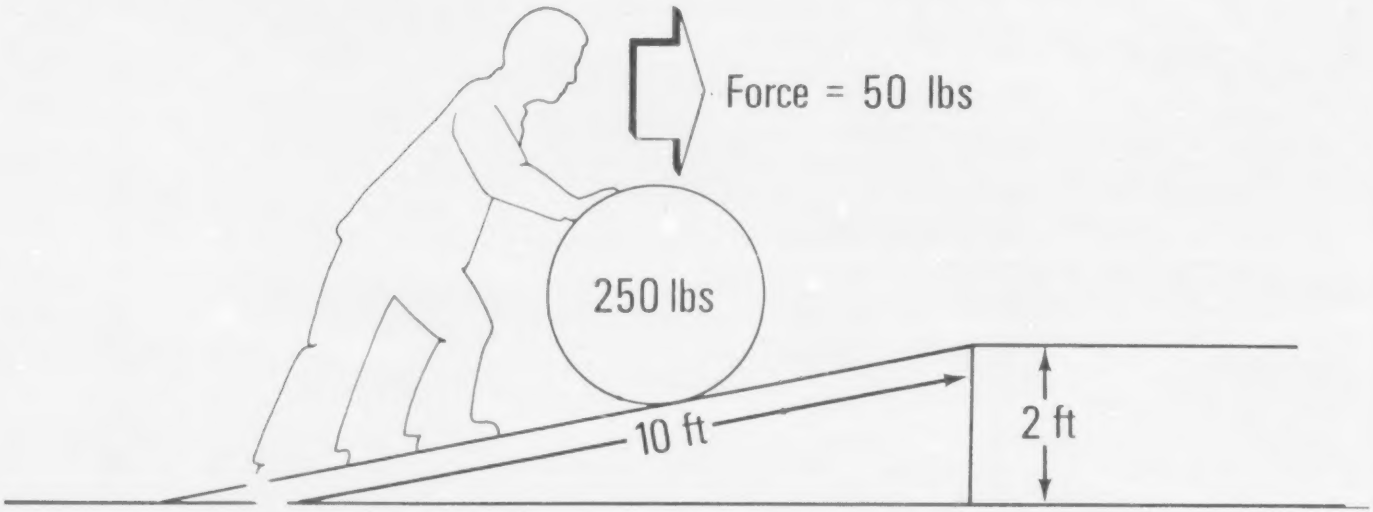

60 lbs
120 lbs
A
C
B
3 IN
6 IN

The Pulley Operates as a Second Class Lever

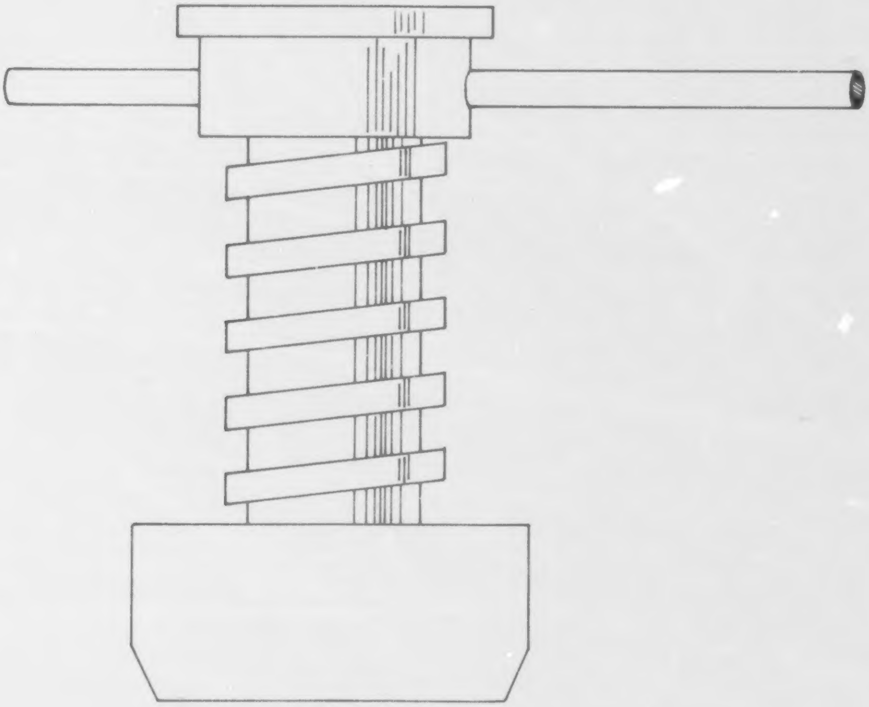

1:1
2:1
2:1
3:1
120 lbs
120 lbs
60 lbs
120 lbs
60 lbs
120 lbs
40 lbs
120 lbs

Gaining Mechanical Advantage through the Use of Pulleys

THE PRINCIPLE OF THE INCLINED PLANE

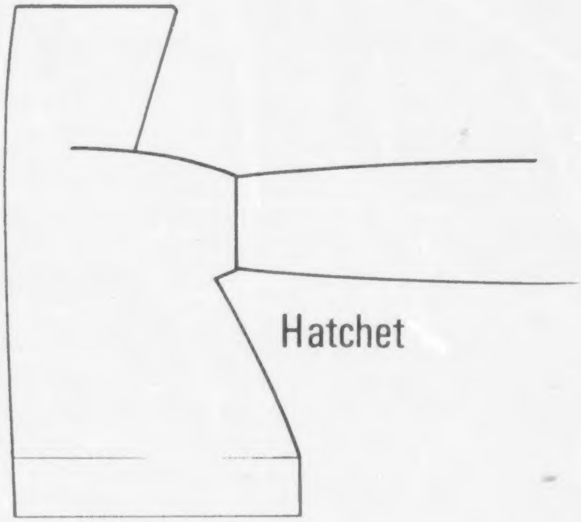

Force = 50 lbs
250 lbs
10 ft
2 ft

THE PRINCIPLE OF THE SCREW

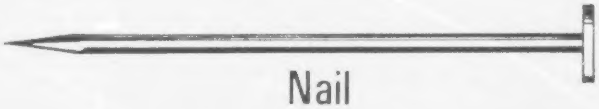


The Screw is Illustrated by an Inclined Plane
Wrapped Around a Shaft

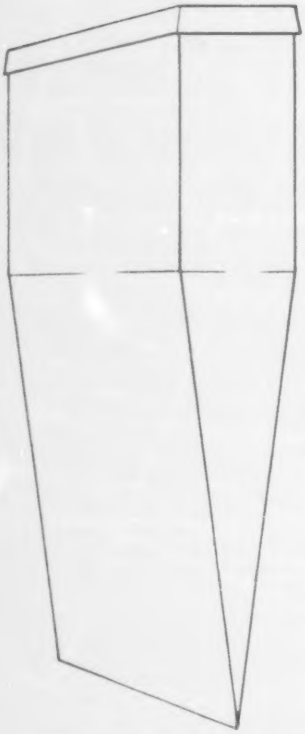
THE PRINCIPLE OF THE WEDGE



Hatchet

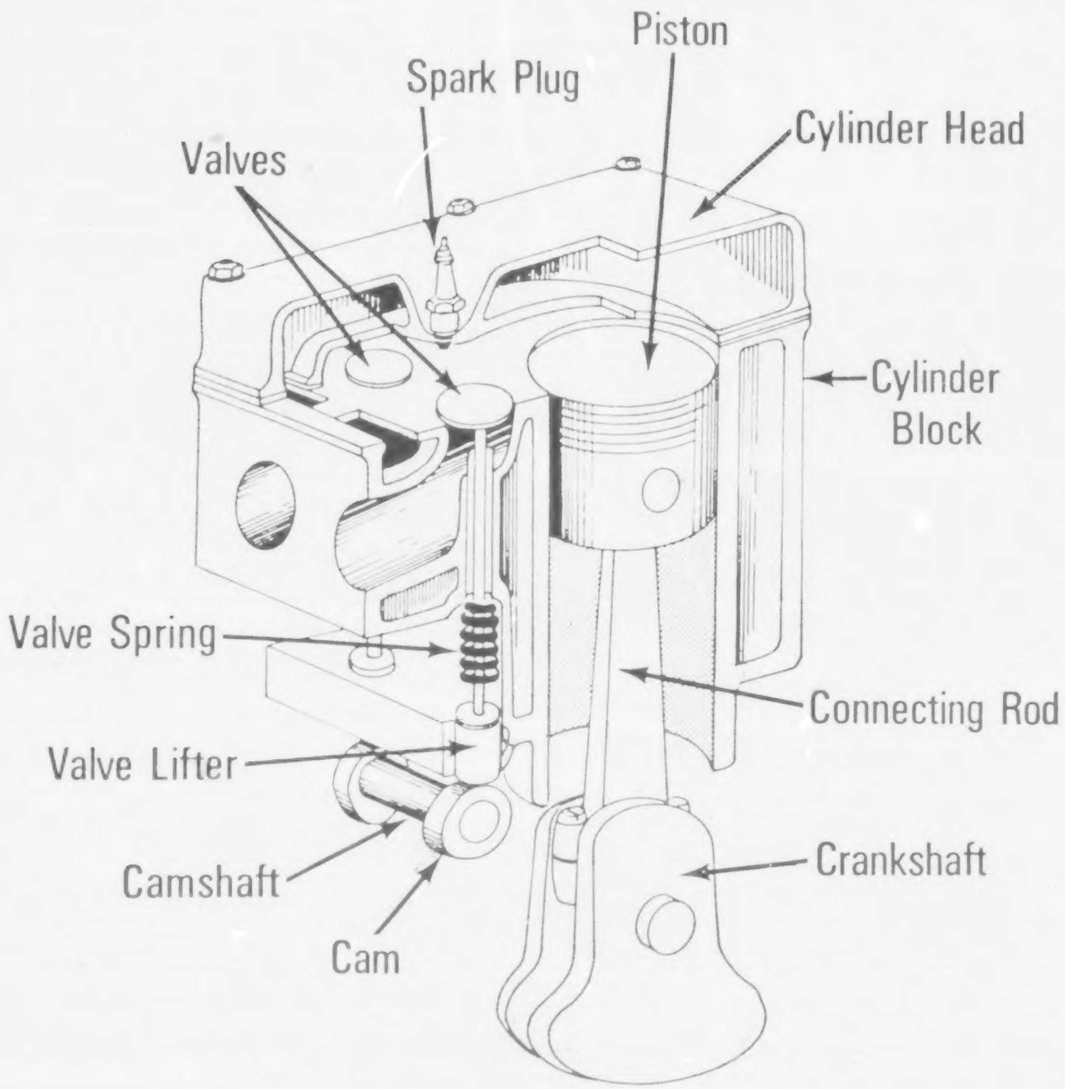


Nail

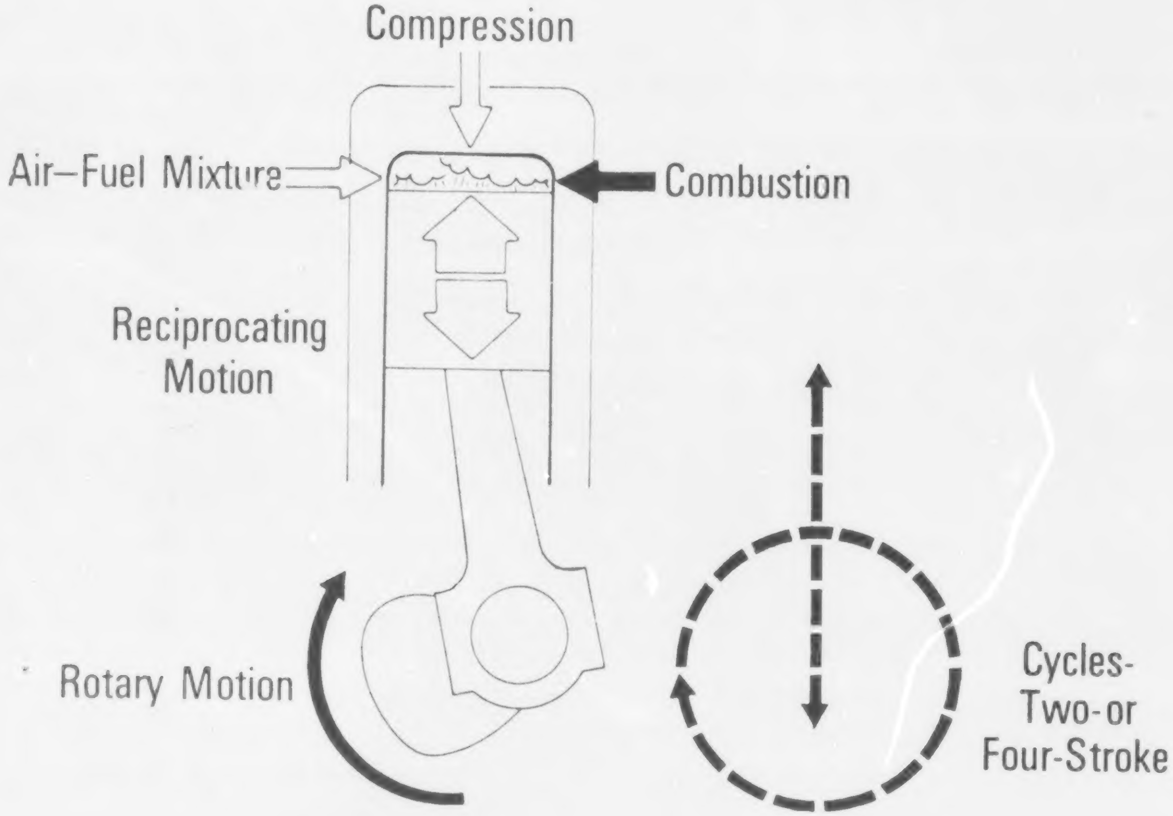


Splitting Wedge

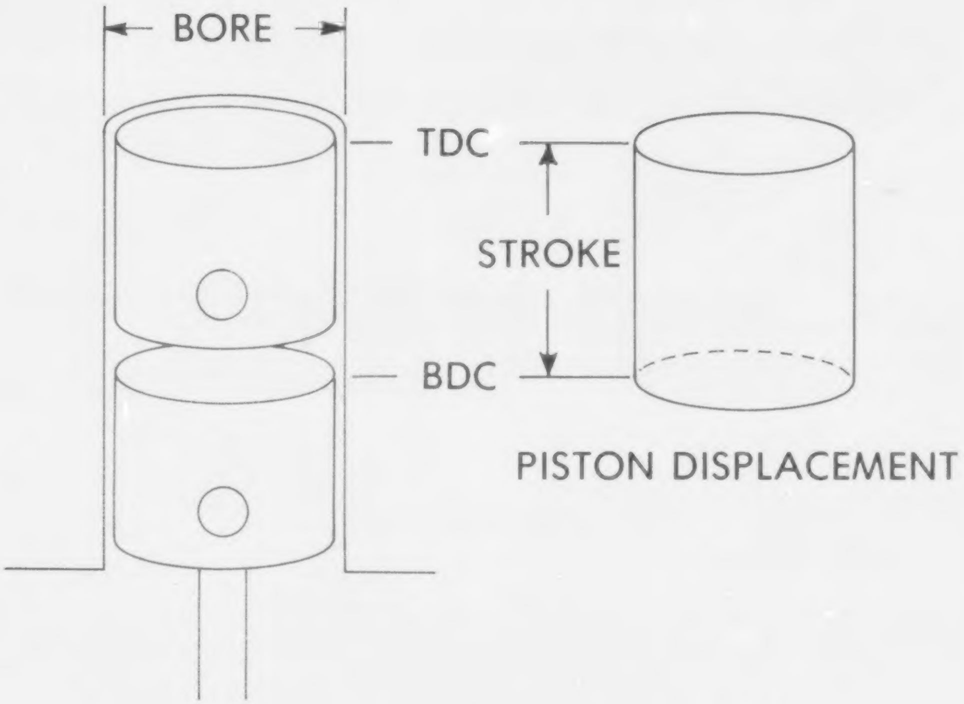
BASIC INTERNAL COMBUSTION ENGINE PARTS


Piston
Spark Plug
Cylinder Head
Valves
Cylinder Block
Valve Spring
Connecting Rod
Valve Lifter
Crankshaft
Camshaft
Cam

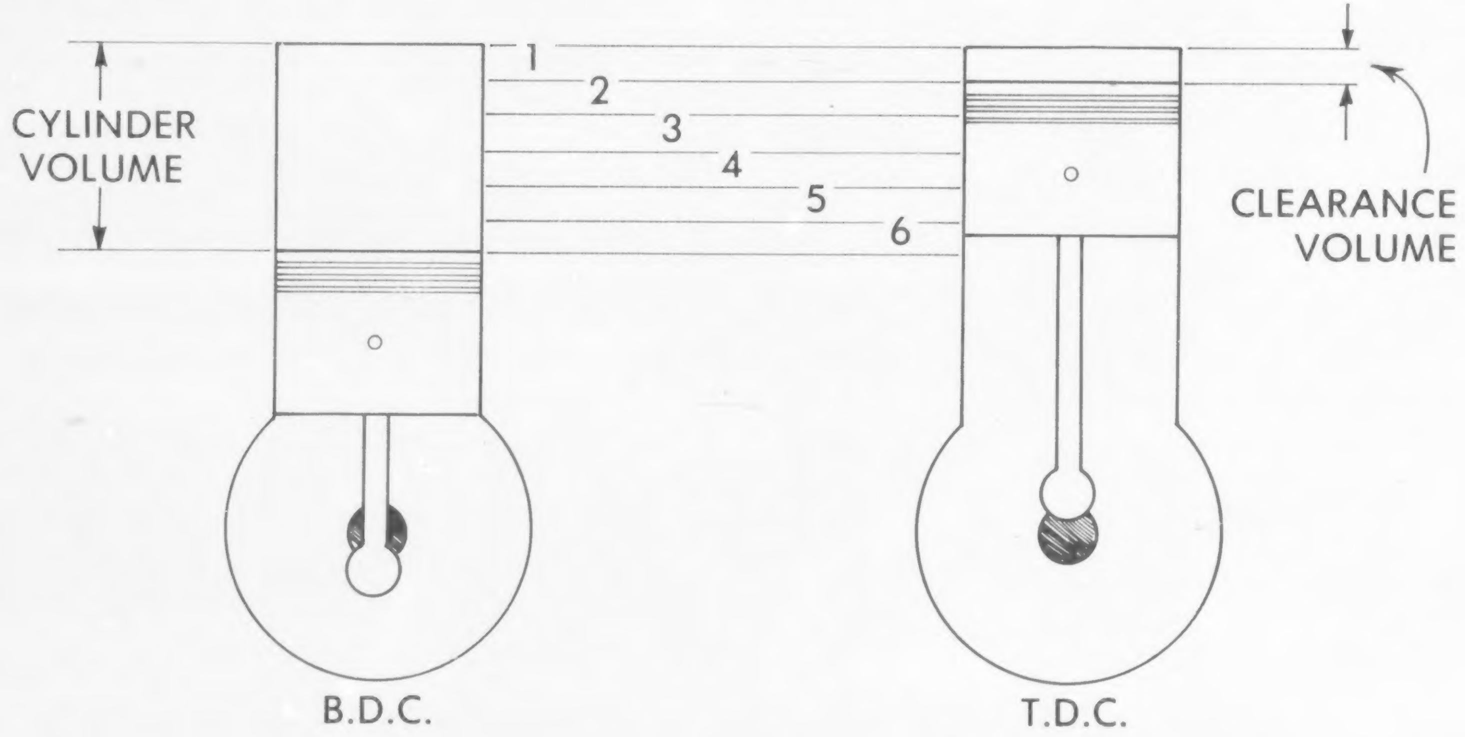
CHEMICAL ENERGY TO ROTARY MOTION


Compression
Air–Fuel Mixture
Combustion
Reciprocating Motion
Rotary Motion
Cycles-
Two-or
Four-Stroke

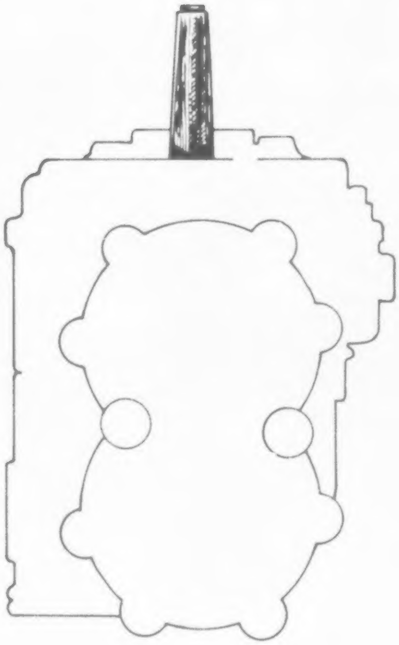
CUBIC INCH DISPLACEMENT


BORE
TDC
STROKE
BDC
PISTON DISPLACEMENT

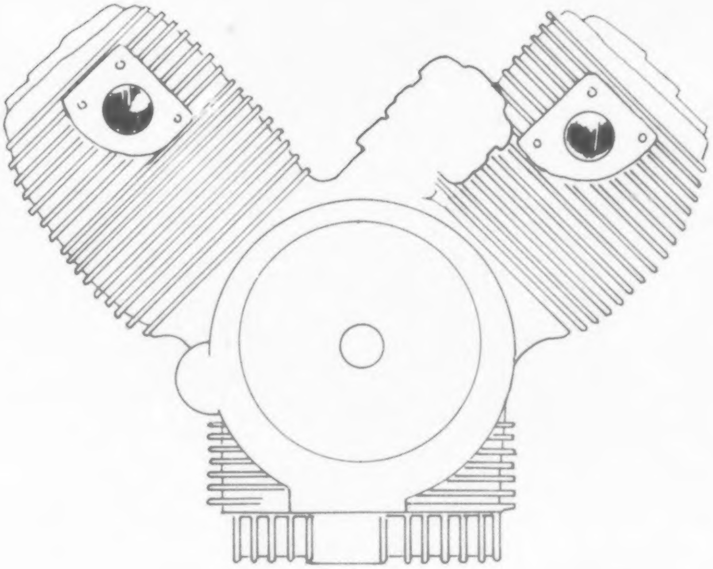
COMPRESSION RATIO 6 TO 1


CYLINDER VOLUME
1
2
3
4
5
6
CLEARANCE VOLUME
B.D.C.
T.D.C.

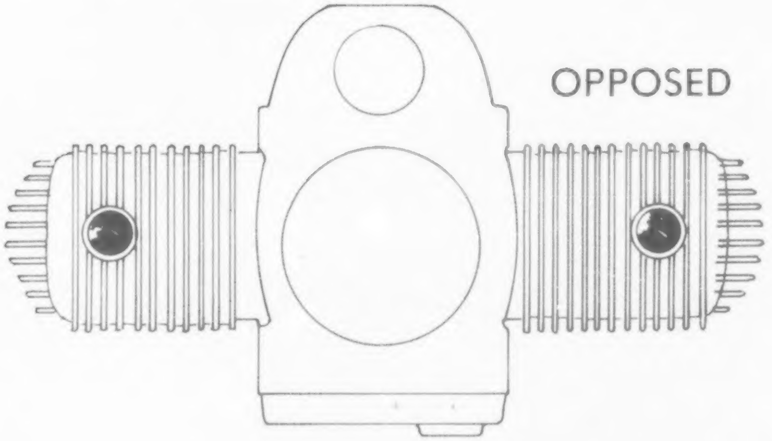
ENGINE DESIGNS



INLINE

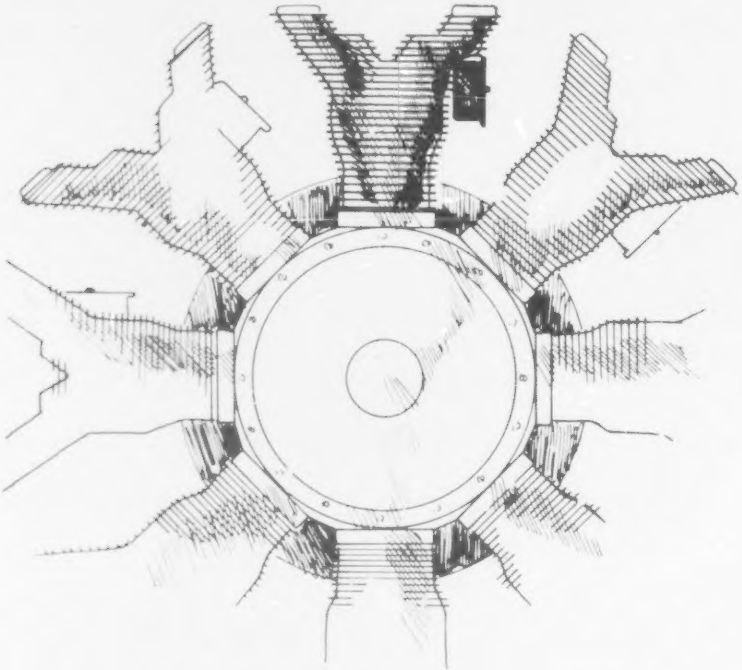


V-TYPE

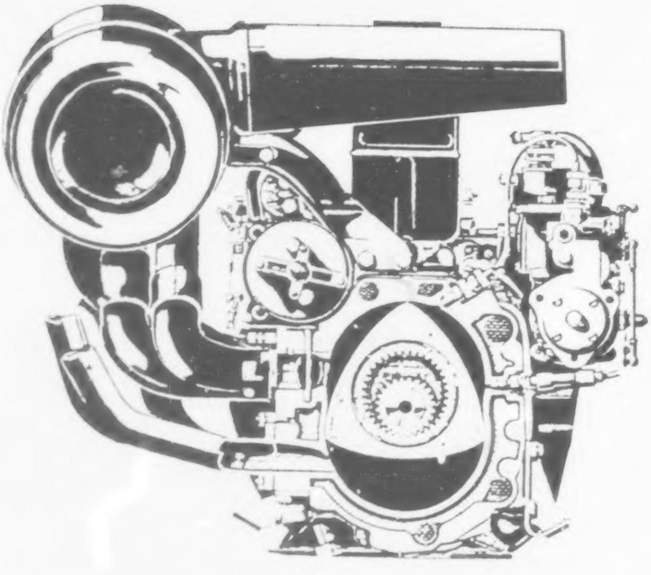


OPPOSED

ENGINE DESIGNS
(Continued)

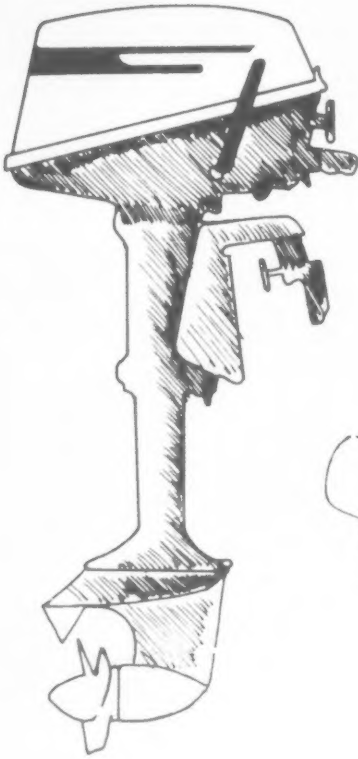


RADIAL

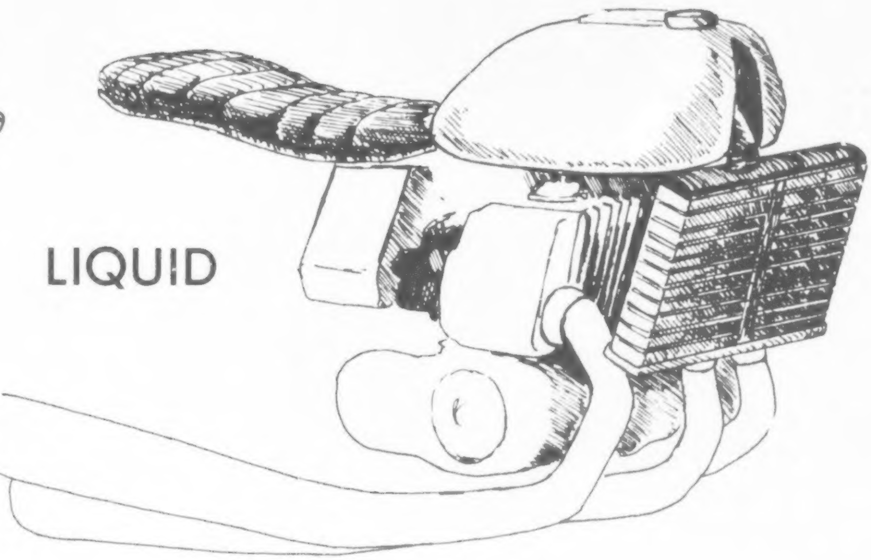


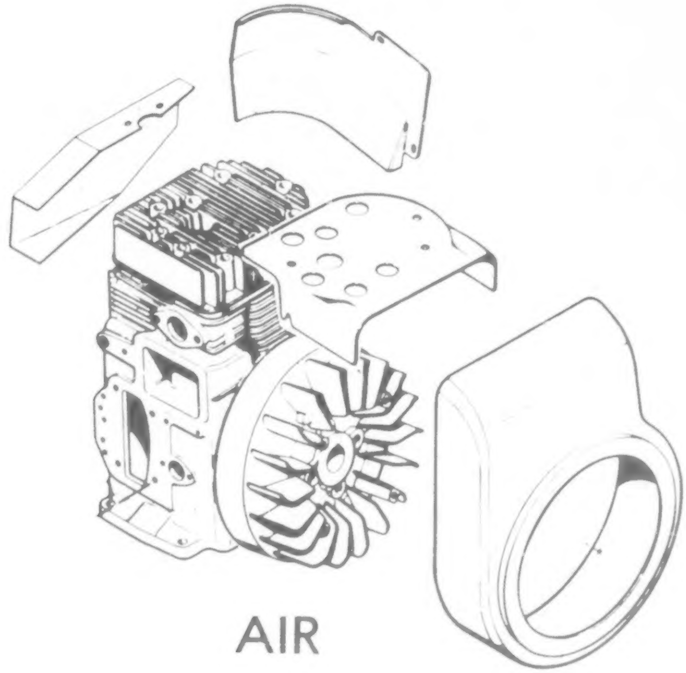
ROTARY

ENGINE COOLING SYSTEMS



LIQUID





AIR

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II

ASSIGNMENT SHEET #1--CALCULATE WORK

Calculate the following problems using the formula for work.

Work = Force x Distance

1. Two men push a 300 pound weight a distance of 50 feet along a warehouse floor. The force necessary to slide the weight is 110 pounds. How much work is accomplished?

2. How much work is accomplished if it takes 92 pounds of force to move a 400 pound object 44 feet?

3. It takes 49 pounds of force to move a 92 pound box 60 feet across the floor. How much work is accomplished?

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II

ASSIGNMENT SHEET #2--CALCULATE HORSEPOWER

Calculate the following problems using the formula for horsepower.

$$HP = \frac{F \times D}{\text{Time (sec)} \times 550}$$

1. A 200 pound man climbs a 40 foot flight of stairs in 20 seconds. How much horsepower does he develop performing the feat?

2. A 1000 pound weight is moved a distance of 60 feet across the floor. The force necessary to move the weight is 200 pounds and the time required to accomplish this is one minute. How much horsepower is required to perform this task?

3. A man pushes a 400 pound weight a distance of 10 feet along the loading dock. The force required to move the weight is 500 pounds. The task is completed in 5 seconds. How much horsepower is produced?

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II

ASSIGNMENT SHEET #3--CALCULATE TORQUE

Calculate the following problems using the formula for torque.

Torque = Force x Radius

1. If a mechanic uses a wrench 8 inches long and applies a 10 pound force to the wrench handle, what is the torque on the bolt?

2. If 15 pounds of force is applied to a wrench 6 inches long, how much is the torque?

3. What is the torque if a force of 8 pounds is applied to a wrench 12 inches long?

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II

ASSIGMENT SHEET #4--CALCULATE CUBIC INCH DISPLACEMENT

Calculate the following problems using the formula for cubic inch displacement. Round answers to nearest whole number.

$$\text{CID} = \frac{\pi \times \text{Bore}^2 \times \text{Stroke} \times \text{Number of cylinders}}{4}$$

1. What is the CID of a cylinder with a 2-inch bore and a 3-inch stroke?

2. Compute the CID of a 4-cylinder engine with 2.5 inch bore and a 2.48 inch stroke.

3. What is the CID of a 6-cylinder engine with a 1.85-inch bore and a 1.969 inch stroke?

BASIC ENGINE PRINCIPLES AND DESIGN
UNIT II

ASSIGNMENT SHEET #5-CALCULATE COMPRESSION RATIO

Calculate the following problems using the formula for compression ratio.

$$\text{Compression Ratio} = \frac{\text{Volume BDC}}{\text{Volume TDC}}$$

1. What is the compression ratio of a cylinder with a volume of 36 cu. in. with the piston at BDC and a TDC volume of 4 cu. in.?

2. Engine A has BDC volume of 16.7 cubic inches and a TDC volume of 2.3 cubic inches. What is the compression ratio?

3. A specific 3 cylinder engine has a total BDC volume of 86 cubic inches and TDC volume of 3 cubic inches in each cylinder. What is the compression ratio of this engine?

4. The maximum practical compression ratio for a specific one cylinder engine is 11.2 to 1. The engine has a BDC volume of 38.77 cubic inches and a TDC volume of 3.5 cubic inches. Is the compression ratio within the practical limits?

BASIC ENGINE PRINCIPLES AND DESIGNS
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. W = F x D
   W = 110 x 50
   W = 5500 foot pounds

2. W = F x D
   W = 92 x 44
   W = 4048 foot pounds

3. W = F x D
   W = 49 x 60
   W = 2940 foot pounds

Assignment Sheet #2

1.
$$HP = \frac{F \times D}{\text{Time (sec)} \times 550}$$
$$HP = \frac{200 \times 40}{20 \times 550}$$
$$HP = \frac{8000}{11000}$$
HP = .727 or approx. 7/10 horsepower

2.
$$HP = \frac{F \times D}{\text{Time (sec)} \times 550}$$
$$HP = \frac{200 \times 60}{60 \times 550}$$
$$HP = \frac{12000}{33{,}000}$$
HP = .364 horsepower

3.
$$HP = \frac{F \times D}{\text{Time (sec)} \times 550}$$
$$HP = \frac{500 \times 10}{5 \times 550}$$
$$HP = \frac{5000}{2750}$$
HP = 1.82 horsepower

Assignment Sheet #3

1. T = F x R
   T = 10 x 8
   T = 80 pound inches

2. $T = F \times R$
   $T = 15 \times 6$
   $T = 90$ pound inches

3. $T = F \times R$
   $T = 8 \times 12$
   $T = 96$ pound inches

Assignment Sheet #4

1. $\text{CID} = \frac{3.1416 \times 2^2 \times 3}{4} \times 1$

   $\text{CID} = \frac{3.1416 \times 4 \times 3}{4} \times 1$

   $\text{CID} = \frac{37.6992}{4} \times 1$

   $\text{CID} = 9.42$ or 9

2. $\text{CID} = \frac{3.1416 \times 2.5^2 \times 3.75}{4} \times 4$

   $\text{CID} = \frac{3.1416 \times 6.25 \times 2.48}{4} \times 4$

   $\text{CID} = \frac{48.6948}{4} \times 4$

   $\text{CID} = 12.1737 \times 4$

   $\text{CID} = 48.6948$ or 49

3. $\text{CID} = \frac{3.1416 \times 1.85^2 \times 1.969}{4} \times 6$

   $\text{CID} = \frac{3.1416 \times 3.4225 \times 1.969}{4} \times 6$

   $\text{CID} = \frac{21.1709}{4} \times 6$

   $\text{CID} = 5.2927 \times 6$

   $\text{CID} = 31.7564$ or 32

Assignment Sheet #5

1. $\begin{array}{r} 9 \\ 4\,\overline{)36} \\ 36 \end{array}$ 9 to 1

2

$$\begin{array}{r} 7.26 \\ 2.3\;\overline{)\,16.700} \\ \underline{161} \\ 60 \\ \underline{46} \\ 140 \\ \underline{138} \\ 2 \end{array}$$

7.26 to 1

3.

$$\begin{array}{r} 28.6 \\ 3\;\overline{)\,86.0} \\ \underline{6} \\ 26 \\ \underline{24} \\ 20 \\ \underline{18} \\ 2 \end{array} \qquad \begin{array}{r} 9.53 \\ 3\;\overline{)\,28.6} \\ \underline{27} \\ 16 \\ \underline{15} \\ 10 \\ \underline{9} \\ 1 \end{array}$$

9.53 to 1

4.

$$\begin{array}{r} 11.07 \\ 3.5\;\overline{)\,38.7700} \\ \underline{35} \\ 37 \\ \underline{35} \\ 270 \\ \underline{245} \\ 25 \end{array}$$

11.07 to 1 Yes

SE - 75-B

BASIC ENGINE PRINCIPLES AND DESIGNS
UNIT II

Name______________________________

TEST

1. Match the terms on the right to the correct definitions. (Terms and definitions are continued on the following page.)

______a. Any agent that produces or tends to produce motion

______b. Rate at which work is done

______c. Ability to do work

______d. Stored energy

______e. Measurement of turning effort

______f. Transmission and control of motion through the use of gears, pulleys, shafts, and other mechanical devices

______g. Bottom dead center

______h. To exercise restraining or directing influence over working forces

______i. Back and forth motion

______j. Energy in motion

______k. Relaying of a working force

______l. Measurement of work accomplished in a given period of time

______m. Pounds per square inch; most common unit for measuring pressure

______n. Series of events or operations that happen regularly and lead back to the starting point

______o. Resistance to relative motion between two bodies in contact

1. Energy
2. Work
3. Force
4. Friction
5. Power
6. Kinetic energy
7. Torque
8. Horsepower
9. Potential energy
10. PSI
11. Cycle
12. TDC
13. Mechanical power
14. Transmission
15. Reciprocating motion
16. BDC
17. Control

______p. Results of force overcoming a resistance over a definite distance

______q. Top dead center

______r. Total volume of air-fuel compressed by the piston in traveling from BDC to TDC

______s. Cubic inch displacement

______t. Action or operation of burning

______u. Distance the piston moves when traveling from TDC to BDC

______v. Diameter of the cylinder

18. Stroke
19. Combustion
20. CID
21. Displacement
22. Bore

2. Discuss the characteristics of energy.

3. List six types of energy.

   a.

   b.

   c.

   d.

   e.

   f.

4. List two forms of available energy.

   a.

   b.

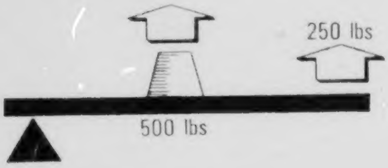
5. List three types of motion.

   a.

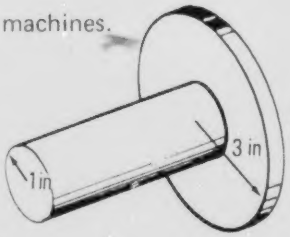
   b.

   c.

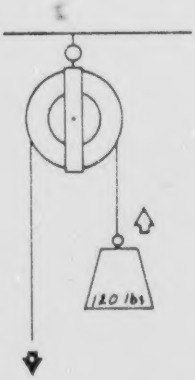
6. Identify the following simple machines.


250 lbs
500 lbs

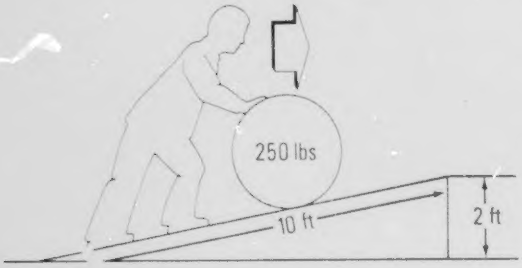
a. ____________________



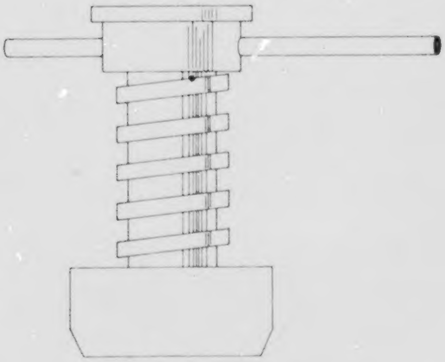
b. ____________________



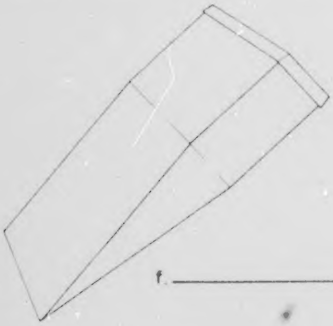
c. ____________________


250 lbs
10 ft
2 ft

d. ____________________



e. ____________________



f. ____________________

7. List three uses of simple machines.

a.

b.

c.

8. Calculate the following problem using the formula for work.

$W = F \times D$

A boy pushes a 200-pound box a distance of 20 feet along the floor. The force necessary to slide the box is 55 pounds. How much work is accomplished?

9. Calculate the following problem using the formula for torque.

$$HP = \frac{F \times D}{\text{Time (sec)} \times 550}$$

Using the problem above, how much horsepower is produced if it takes 20 seconds to slide the box along the floor?

10. Calculate the following problem using the formula for torque.

$T = F \times R$

What is the torque if a force of 40 pounds is applied to a wrench two feet long?

11. State the main theoretical concept of heat engines.

12. Distinguish between types of heat engines by placing an "X" in front of the description of an internal combustion engine.

______a. Fuel is burned inside the engine to produce heat energy which the engine converts to motion

______b. Fuel produces heat energy outside the engine and is transmitted to the engine by water or other means to power the engine which converts heat energy to motion

13. Match the parts of a basic internal combustion engine to the correct descriptions.

_____a. Hollow tube closed at one end by the cylinder head

_____b. Cylindrical object which slides in the tube, fitting tightly to seal other end of tube

_____c. Straight rod with one end connected to a pivot in the piston so lower end can swing with the rotation of the crankshaft

_____d. Main shaft of an engine which, in conjunction with connecting rods, changes reciprocating motion of pistons into rotary motion

_____e. Movable plug to open and close the cylinder in order to let in air-fuel mixture and to remove the burned fuel from the cylinder

_____f. Circular devices fitted to the upper end of the piston which seal the piston to the cylinder to control loss of compression and lubricating oil

_____g. Passage behind the valves which conducts fuel and air into and exhaust out of the cylinder

1. Port
2. Crankshaft
3. Rings
4. Cylinder
5. Connecting rod
6. Piston
7. Valve

14. Describe the process by which an internal combustion engine converts chemical energy into rotary motion.

15. Calculate the following problem using the formula for engine cubic inch displacement.

$$CID = \frac{\pi \times Bore^2 \times Stroke}{4} \times \text{Number of cylinders}$$

What is the cubic inch displacement of a 2 cylinder engine that has a bore of 2.3 and a stroke of 3.2 inches?

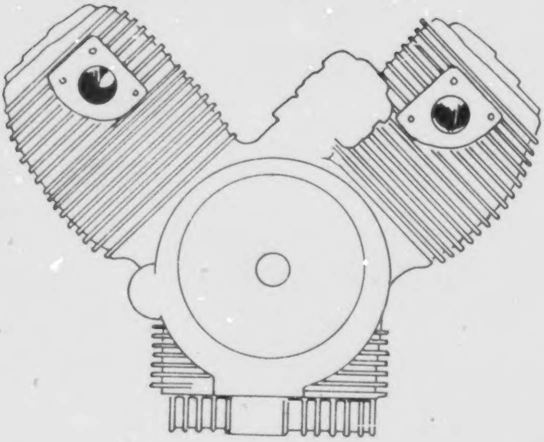
16. Calculate the following problem using the formula for compression ratio.

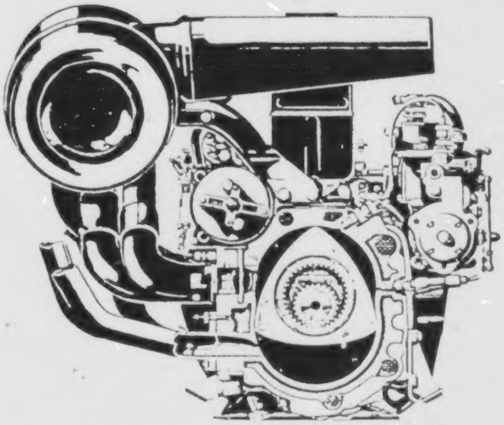
$$\text{Compression ratio} = \frac{\text{Volume BDC}}{\text{Volume TDC}}$$

A specific 2 cylinder engine has a CID of 37 inches. Each cylinder has a BDC volume of 16.5 cubic inches and a TDC volume of 3.3 cubic inches. What is the compression ratio?

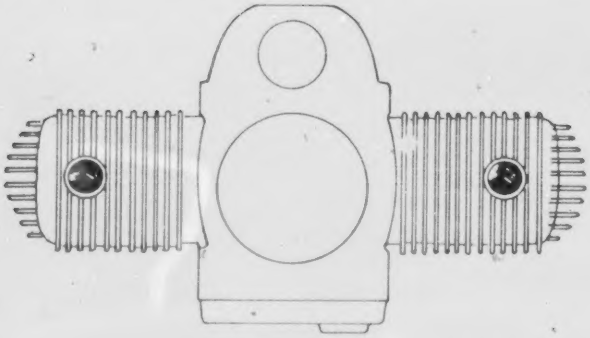
17. Discuss the purposes of a flywheel.

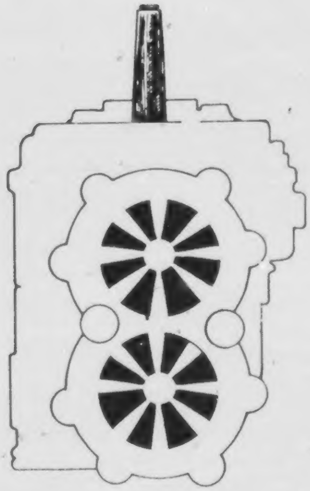
18. Identify the following types of engine design.



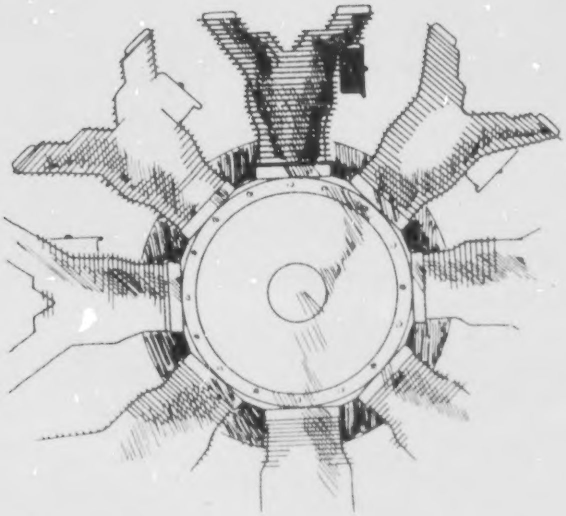


a. ____________________ b. ____________________



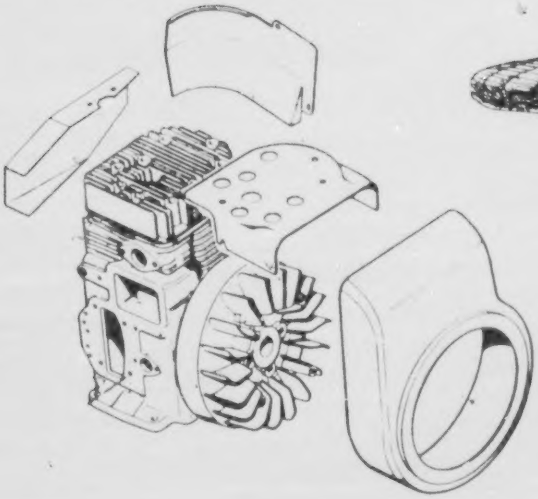


c. ____________________ d. ____________________

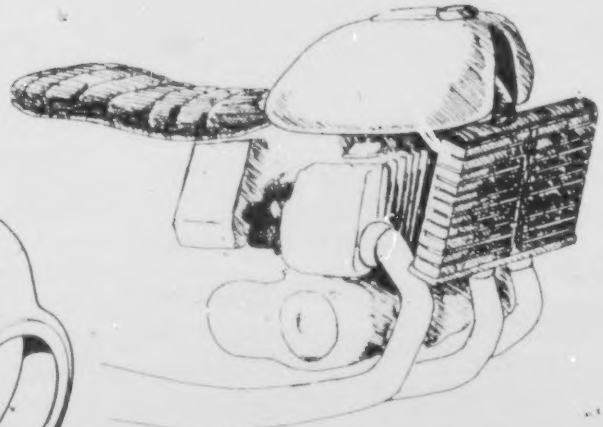


e. ______________________

19. Identify the following types of engine cooling systems.



a. ______________________



b. ______________________

BASIC ENGINE PRINCIPLES AND DESIGNS
UNIT II

ANSWERS TO TEST

1.

a.	3	g.	16	m.	10	s.	20
b.	5	h.	17	n.	11	t.	19
c.	1	i.	15	o.	4	u.	18
d.	9	j.	6	p.	2	v.	22
e.	7	k.	14	q.	12		
f.	13	l.	8	r.	21		

2. Discussion should indlude:
   a. Energy is ever present
   b. Energy cannot be created or destroyed
   c. Energy can only be changed from one kind to another

3. a. Light
   b. Heat
   c. Chemical
   d. Electrical
   e. Nuclear
   f. Mechanical

4. a. Potential
   b. Kinetic

5. a. Reciprocating
   b. Rotary
   c. Linear

6. a. Lever
   b. Wheel and axle
   c. Pulley
   d. Inclined plane

e. Screw

f. Wedge

7. a. Increase force

b. Change direction

c. Change speed

8. W = F x D
W = 55 lbs x 20 ft
W = 1100 foot pounds

9\.
$$HP = \frac{F \times D}{\text{Time (sec)} \times 550}$$
$$HP = \frac{55 \times 20}{20 \times 550}$$
$$HP = \frac{1100}{11000}$$
$$HP = .10$$

10. T = F x R
T = 40 x 2
T = 80 pound feet

11. Converts heat energy into usable power in the form of motion

12. a

13. a. 4

b. 6

c. 5

d. 2

e. 7

f. 3

g. 1

14. Description should include:

a. Gasoline and air are introduced into the upper end of the cylinder

b. Air-fuel mixture is ignited and burned, producing heat energy

c. Heat energy causes the cylinder gases to expand

d. Expansion of the burning gases pushes piston down the cylinder

e. Downward motion of piston transmits force to the crankshaft through the connecting rod to produce rotary motion

15. 26.6 CID

16. 5 to 1

17. Discussion should include:
    a. Smooth out surges of the power strokes
    b. Maintain crankshaft motion between power strokes
    c. Develop kinetic energy when spinning
    d. Provide gear teeth on outer rim for starting motor operation

18. a. V-type
    b. Rotary
    c. Opposed
    d. In-line
    e. Radial

19. a. Air
    b. Liquid

PRINCIPLES OF OPERATION - FOUR-STROKE CYCLE
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the components of a four-stroke cycle engine, the parts of a camshaft lobe, and the types of valve arrangements. The student should also be able to discuss the operation of the four-stroke cycle engine, valve timing and overlap. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the principles of operation of a four-stroke cycle engine to the correct definitions.
2. Identify the components of a four-stroke cycle engine.
3. Discuss the operation of a four-stroke cycle engine.
4. List two factors that determine the firing order of a multi-cylinder engine.
5. Identify the parts of a camshaft lobe.
6. Discuss valve timing and overlap.
7. Identify types of valve arrangements.

PRINCIPLES OF OPERATION - FOUR-STROKE CYCLE
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate location of components on a live engine.

   G. Demonstrate the operation of the four strokes in a cycle.

   H. Provide examples of the different types of valve arrangements.

   I. Disassemble an engine so that students can identify individual components.

   J. Give test.

II. Student

   A. Read objective sheet.

   B. Study information sheet.

   C. Observe demonstration of operation of the four strokes.

   D. Locate the components on a live engine.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Components of a Four-Stroke Cycle Engine

      2. TM 2--Four-Stroke Cycle

3. TM 3--Valve Action on Intake Stroke
4. TM 4--Valve Action on Compression Stroke
5. TM 5--Valve Action on Power Stroke
6. TM 6--Valve Action on Exhaust Stroke
7. TM 7--Cam Lobe Contour Design
8. TM 8--Valve Timing and Overlap
9. TM 9--Valve Arrangements

D. Test

E. Answers to test

II. References

A. Armstrong, Ivan. *Auto Mechanics, Volume One.* Stillwater, Oklahoma: Oklahoma State Department of Vocational and Technical Education, 1976.

B. *Small Engine Service Repair and Maintenance.* St. Paul, Minnesota: Departments of Agricultural Education and Agricultural Engineering, University of Minnesota, 1968.

C. *Small Gasoline Engines.* University Park, Pennsylvania: College of Agriculture, The Pennsylvania State University, 1969.

PRINCIPLES OF OPERATION - FOUR-STROKE CYCLE
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Intake stroke--Downward movement of piston which permits fuel-air mixture to enter cylinder

   B. Compression stroke--Upward movement of piston which compresses fuel-air mixture

   C. Power stroke--Downward piston movement caused by spark ignition of compressed fuel-air mixture

   D. Exhaust stroke--Upward piston movement which expels burnt gases from cylinder

   E. Valve--Device for alternately opening and closing a passage

   F. Intake valve--Engine component which opens to allow fuel-air mixture to enter cylinder during intake stroke

   G. Exhaust valve--Engine component which opens during exhaust stroke and allows burnt gases to be expelled from cylinder

   H. Overlap--Brief period when both intake and exhaust valves are open

   I. Cam lobe--Off-center or eccentric enlargement on the camshaft which converts rotary motion to reciprocating motion for operating a valve

   J. Camshaft--Shaft which contains lobes or cams to operate engine valves

   K. Valve lifter or tappet--Push rod or plunger placed between the cam and the valve on an engine

   L. Valve seat--Matched surface upon which the valve rests

   M. Valve spring--Spring attached to a valve to return it to the seat

II. Components of a four-stroke cycle engine (Transparency 1)

   A. Cylinder block

   B. Cylinder head

   C. Piston

   D. Connecting rod

INFORMATION SHEET

E. Crankshaft

F. Camshaft

G. Valves

H. Valve spring

I. Valve lifter

J. Cam lobe

III. Operation of four-stroke cycle engine (Transparencies 2, 3, 4, 5 and 6)

(NOTE: Four-stroke refers to the number of times the piston moves up and down in the cylinder to complete one cycle of operation. Four-stroke cycle engines are commonly called four cycle engines.)

A. Intake stroke

1. Cycle starts with piston at uppermost position in cylinder (TDC) with intake valve open and exhaust valve closed

2. As the piston moves down the cylinder, it draws air-fuel mixture into the cylinder from the carburetor

3. When the piston reaches the bottom of the cylinder (BDC), the intake valve closes

B. Compression stroke

1. Air-fuel mixture is compressed tightly as the piston moves up the cylinder

2. Compression of the fuel creates heat which prepares the fuel for instant ignition

C. Power stroke

1. As the piston reaches the top of the cylinder on compression stroke, a spark from the ignition system ignites the air-fuel mixture

2. Burning gases expand very rapidly and force the piston down the cylinder

INFORMATION SHEET

D. Exhaust stroke

1. As the piston reaches the bottom of the cylinder on power stroke, the exhaust valve opens
2. Piston travels up the cylinder, forcing the burned gases out of the cylinder into the exhaust manifold

(NOTE: The complete cycle takes two rotations of the crankshaft or 720 degrees of rotation.)

IV. Factors that determine the firing order of a multi-cylinder engine

A. Design of the crankshaft

B. Location of the cams on the camshaft

V. Camshaft lobe (Transparency 7)

A. Lobe

B. Nose

C. Flank

D. Base circle

E. Lift

VI. Valve timing and overlap (Transparency 8)

(NOTE: Valve angles given below are approximated; the actual angles will vary widely depending upon engine design.)

A. Intake valve--Opens approximately 15 degrees before the intake stroke begins and remains open through intake stroke and 20 degrees into compression stroke

(NOTE: The intake valve is open approximately 235 degrees of the 720 degree cycle.)

B. Exhaust valve--Opens approximately 40 degrees before the exhaust stroke begins and remains open through exhaust stroke and 20 degrees into the intake stroke

(NOTE: The exhaust valve is open approximately 235 degrees of the 720 degree cycle.)

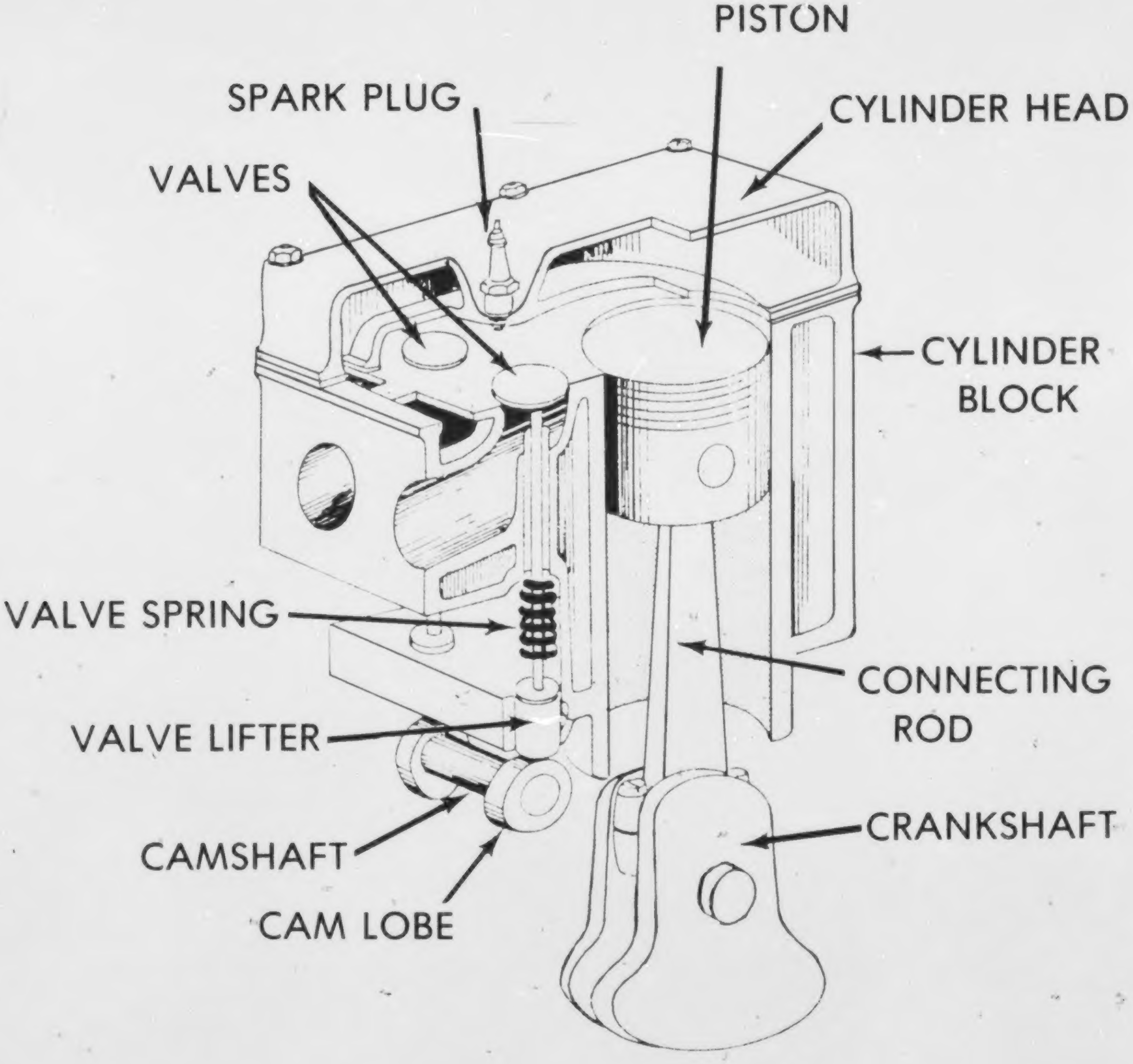
C. Valve overlap--Both intake and exhaust valves are partially open; the intake valve is starting to open while the exhaust valve is not yet closed

INFORMATION SHEET

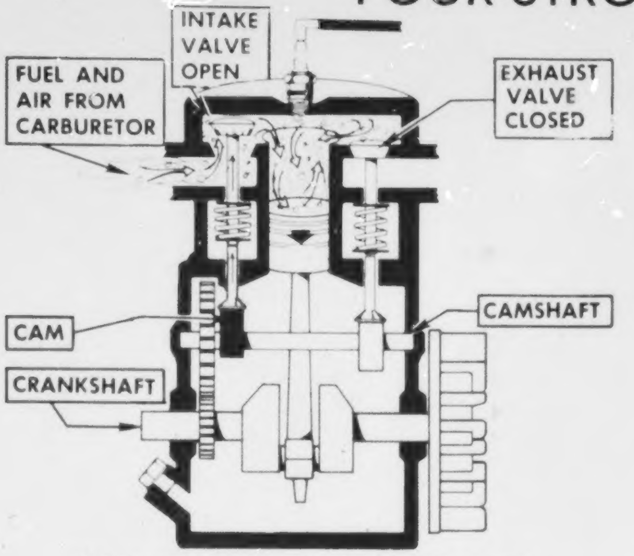
VII. Types of valve arrangements (Transparency 9)

- A. L-Head
- B. F-Head
- C. T-Head
- D. I-Head
- E. Overhead cam

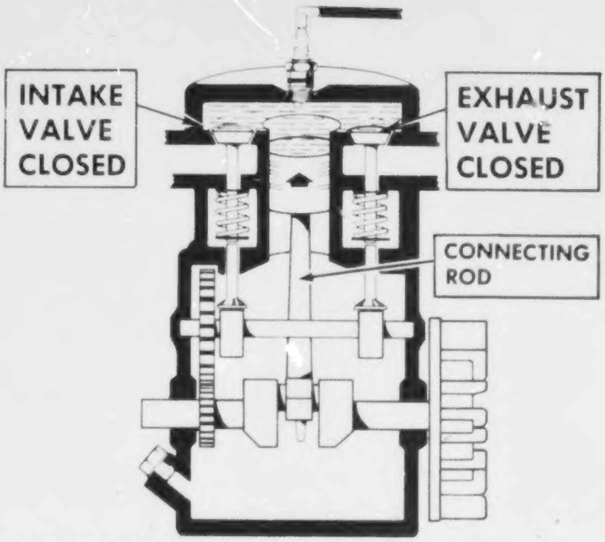
COMPONENTS OF A FOUR-STROKE CYCLE ENGINE


PISTON
SPARK PLUG
CYLINDER HEAD
VALVES
CYLINDER BLOCK
VALVE SPRING
CONNECTING ROD
VALVE LIFTER
CRANKSHAFT
CAMSHAFT
CAM LOBE

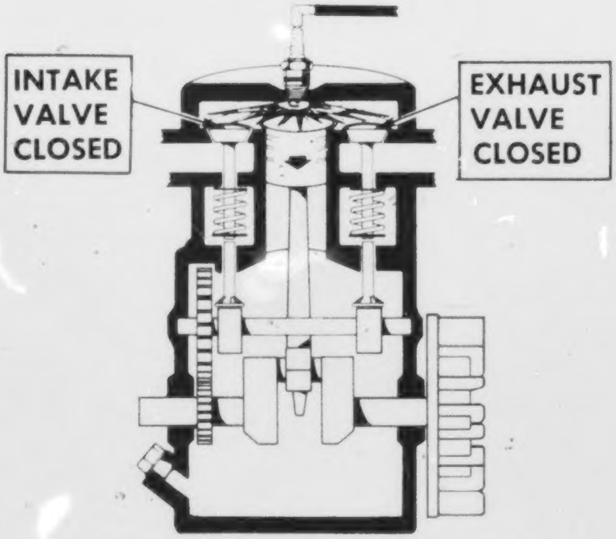
FOUR-STROKE CYCLE


INTAKE VALVE OPEN
FUEL AND AIR FROM CARBURETOR
EXHAUST VALVE CLOSED
CAM
CAMSHAFT
CRANKSHAFT

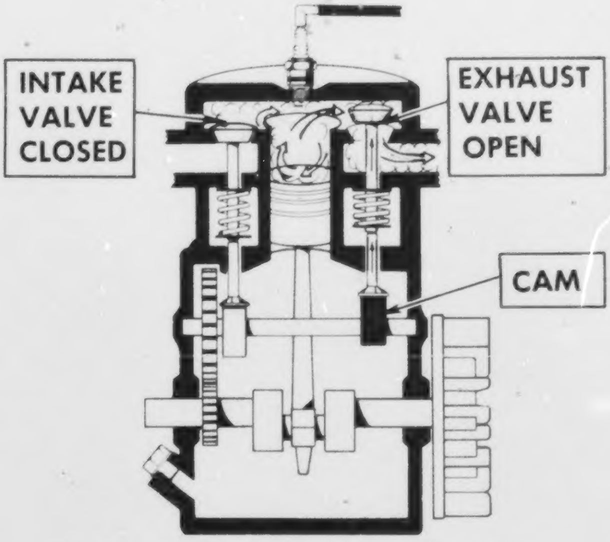
PISTON INTAKE STROKE


INTAKE VALVE CLOSED
EXHAUST VALVE CLOSED
CONNECTING ROD

PISTON COMPRESSION STROKE

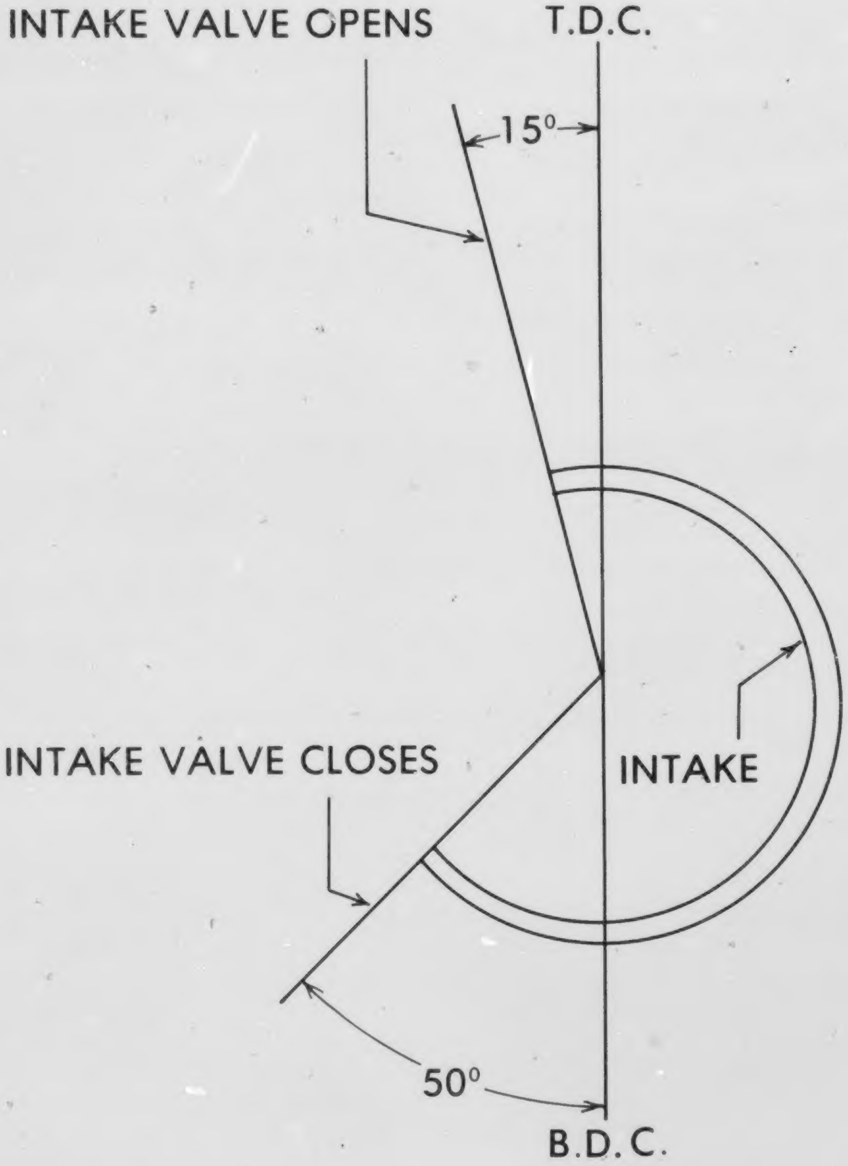

INTAKE VALVE CLOSED
EXHAUST VALVE CLOSED

PISTON POWER STROKE

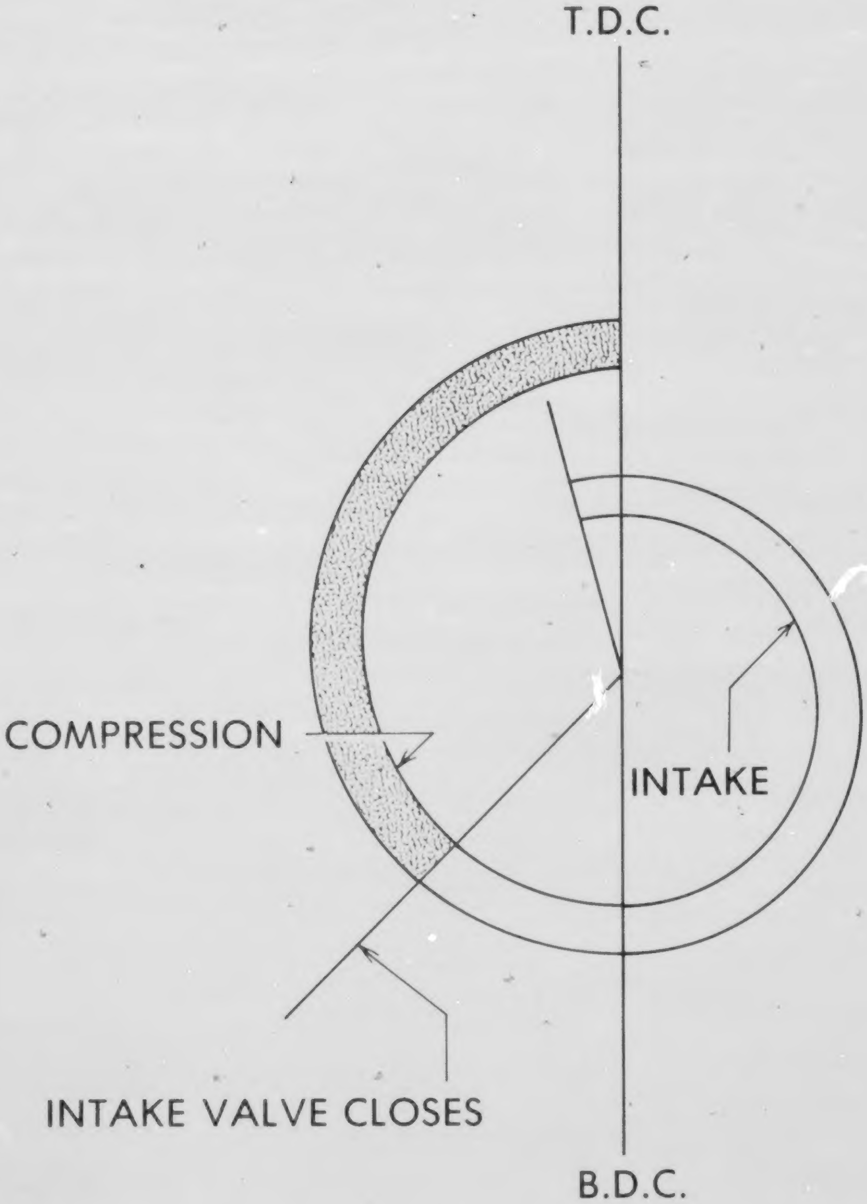

INTAKE VALVE CLOSED
EXHAUST VALVE OPEN
CAM

PISTON EXHAUST STROKE

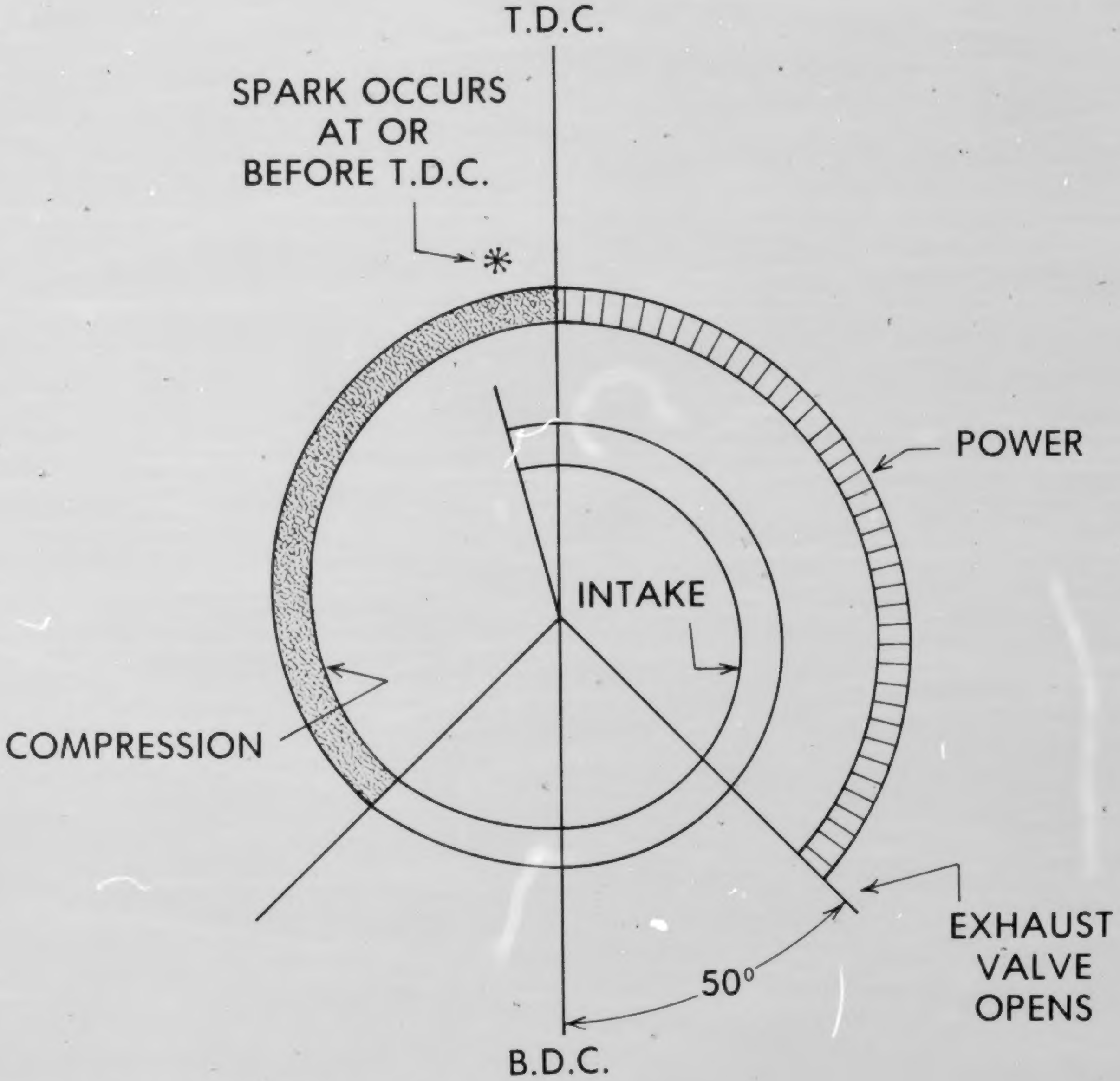
VALVE ACTION ON INTAKE STROKE


INTAKE VALVE OPENS
T.D.C.
15°
INTAKE VALVE CLOSES
INTAKE
50°
B.D.C.

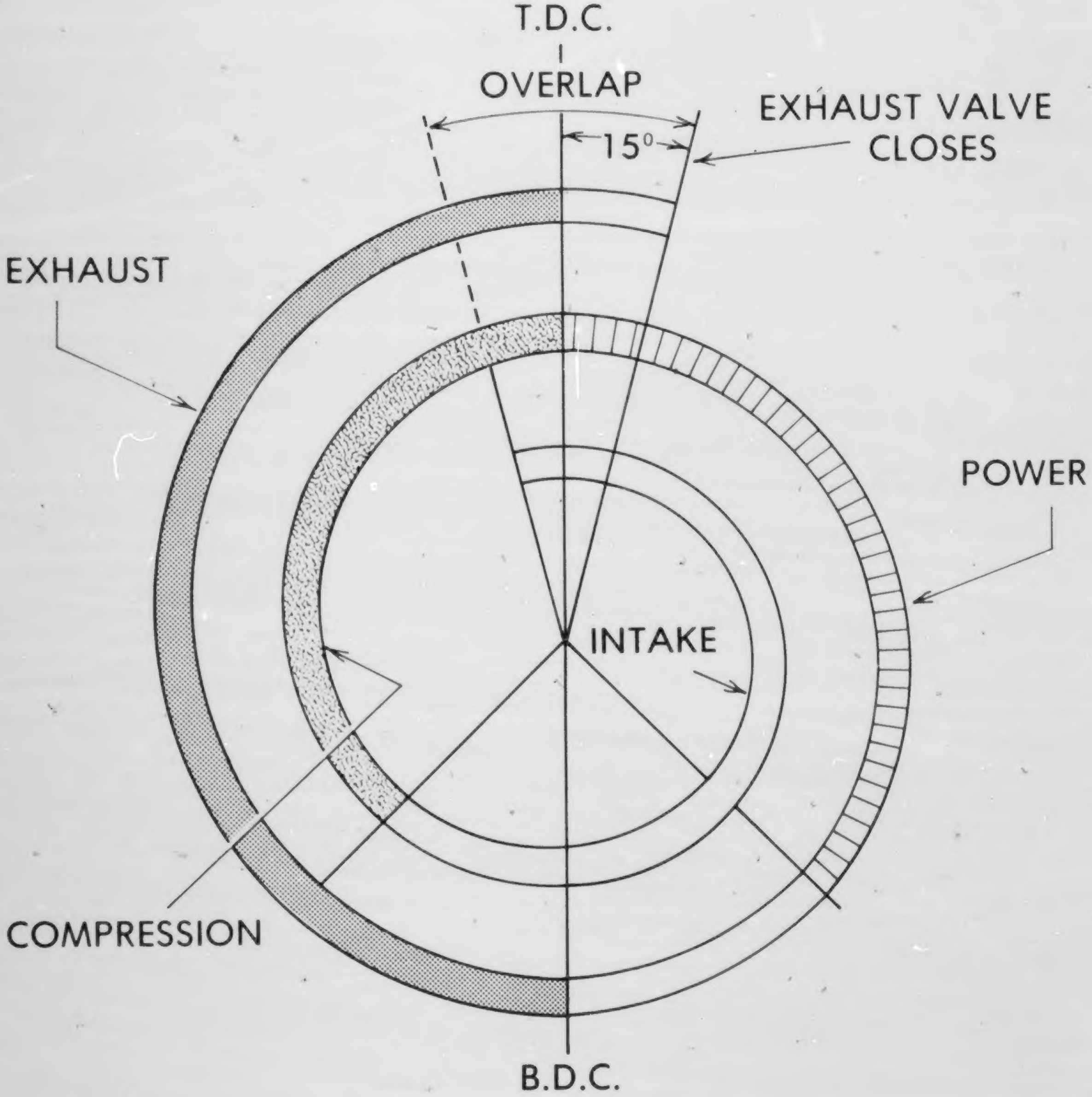
VALVE ACTION ON COMPRESSION STROKE


T.D.C.
COMPRESSION
INTAKE
INTAKE VALVE CLOSES
B.D.C.

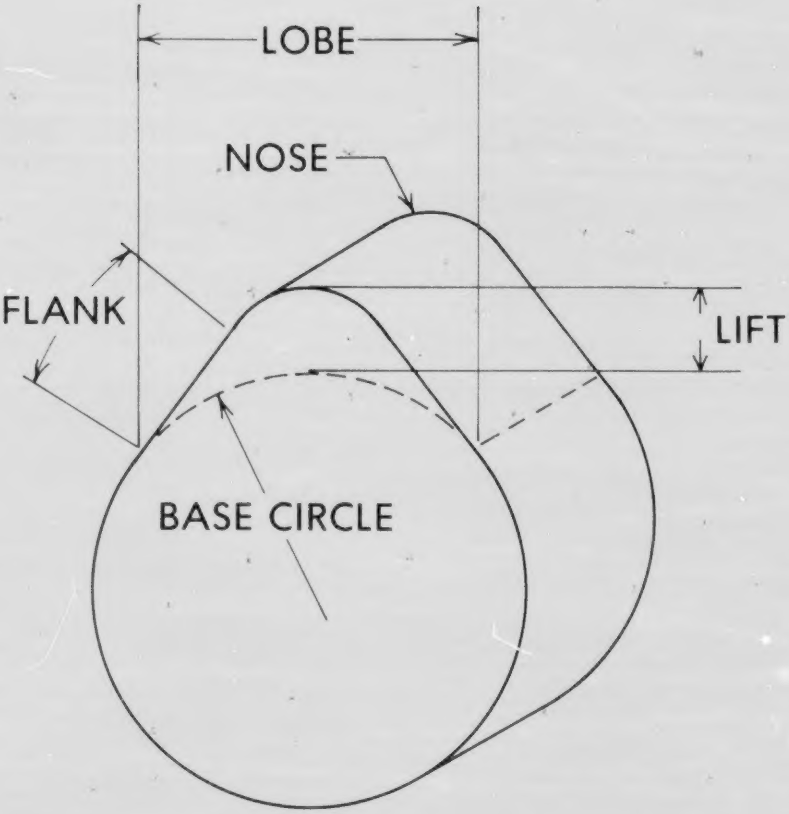
VALVE ACTION ON POWER STROKE


T.D.C.
SPARK OCCURS AT OR BEFORE T.D.C.
*
POWER
INTAKE
COMPRESSION
EXHAUST VALVE OPENS
50°
B.D.C.

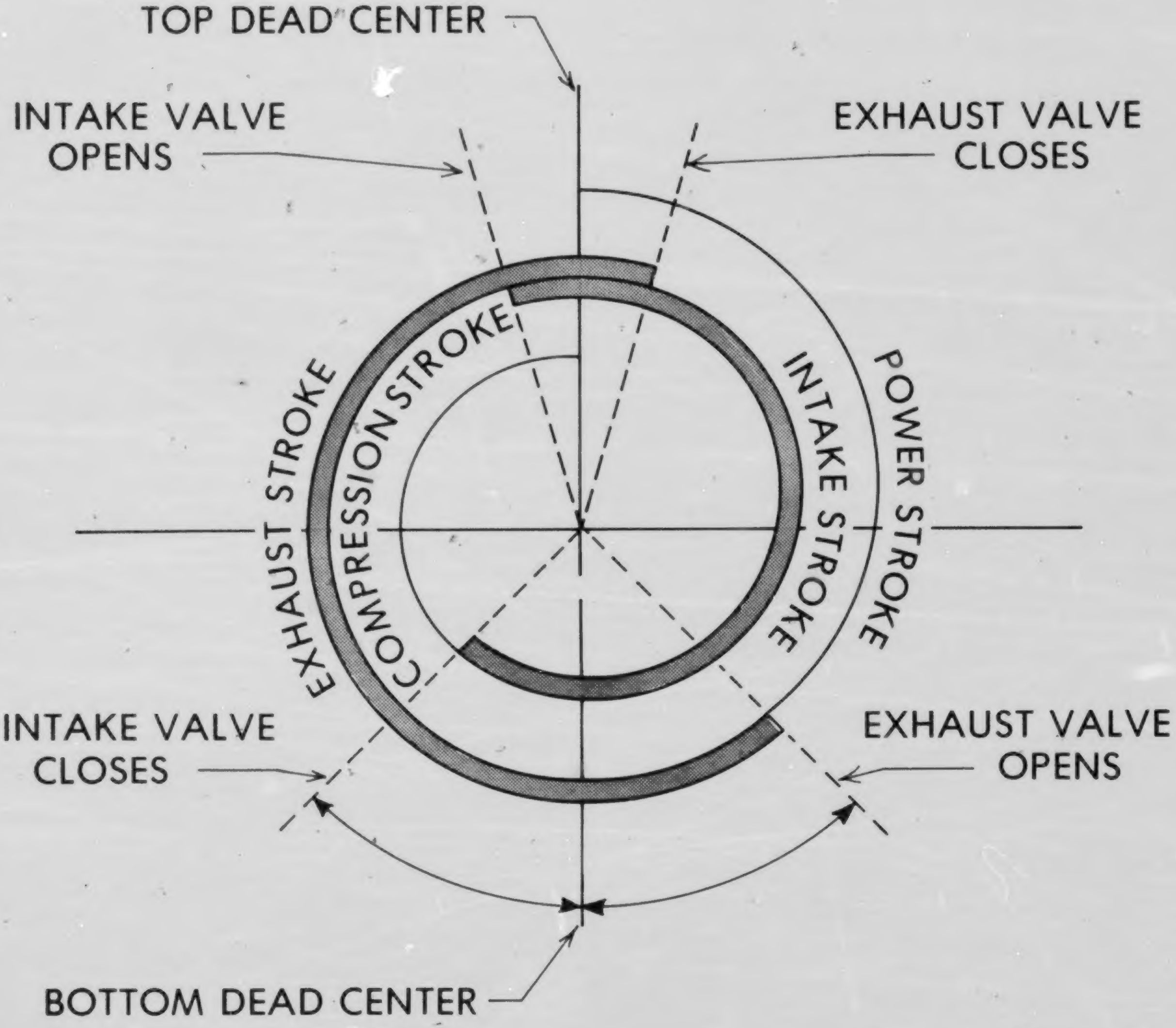
VALVE ACTION ON EXHAUST STROKE


T.D.C.
OVERLAP
15°
EXHAUST VALVE CLOSES
EXHAUST
POWER
INTAKE
COMPRESSION
B.D.C.

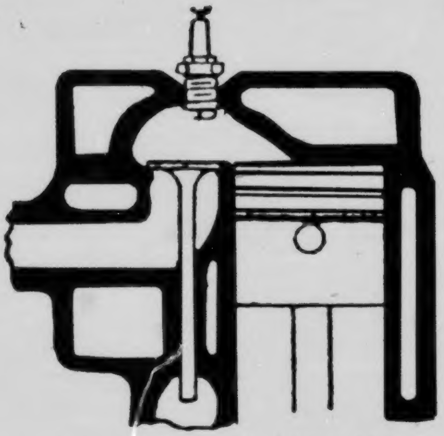
CAM LOBE CONTOUR DESIGN

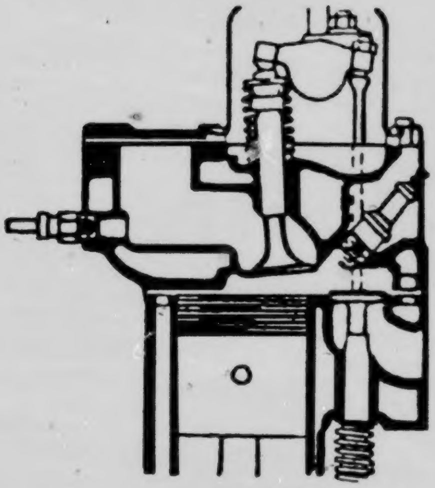

LOBE
NOSE
FLANK
LIFT
BASE CIRCLE

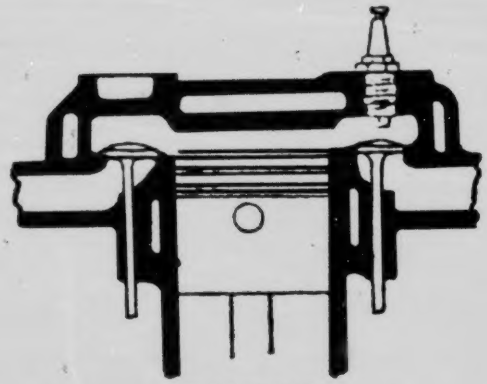
VALVE TIMING AND OVERLAP

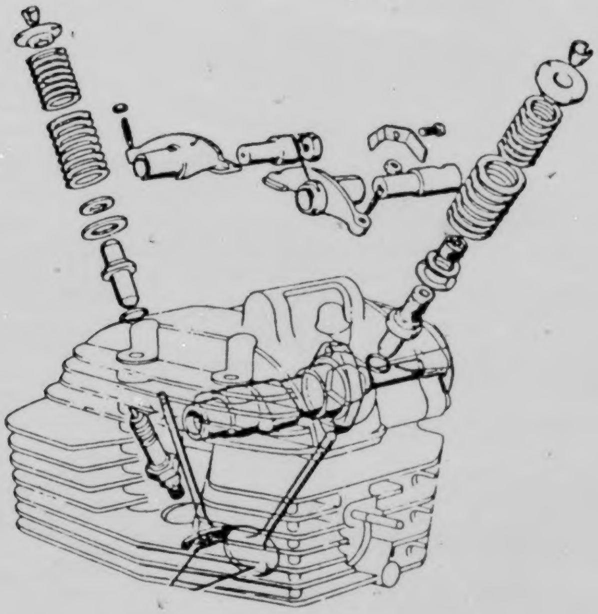

TOP DEAD CENTER
INTAKE VALVE OPENS
EXHAUST VALVE CLOSES
COMPRESSION STROKE
EXHAUST STROKE
INTAKE STROKE
POWER STROKE
INTAKE VALVE CLOSES
EXHAUST VALVE OPENS
BOTTOM DEAD CENTER

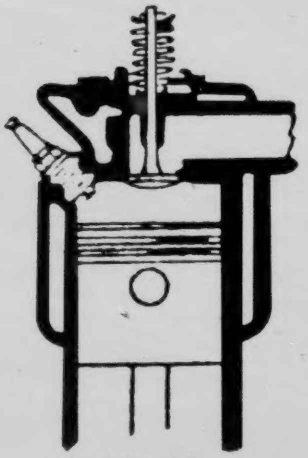
VALVE ARRANGEMENTS


L-HEAD


F-HEAD


T-HEAD


OVERHEAD CAM


I-HEAD

PRINCIPLES OF OPERATION - FOUR-STROKE CYCLE
UNIT III

NAME ________________

TEST

1. Match the terms on the right to the correct definitions.

______a. Spring attached to a valve to return it to the seat

______b. Device for alternately opening and closing a passage

______c. Off-center or eccentric enlargement on the camshaft which converts rotary motion to reciprocating motion for operating a valve

______d. Brief period when both intake and exhaust valves are open

______e. Upward movement of piston which compresses fuel-air mixture

______f. Downward movement of piston which permits fuel air mixture to enter cylinder

______g. Push rod or plunger placed between the cam and the valve on an engine

______h. Matched surface upon which the valve rests

______i. Shaft which contains lobes or cams to operate engine valves

______j. Engine component which opens during exhaust stroke and allows burnt gases to be expelled from cylinder

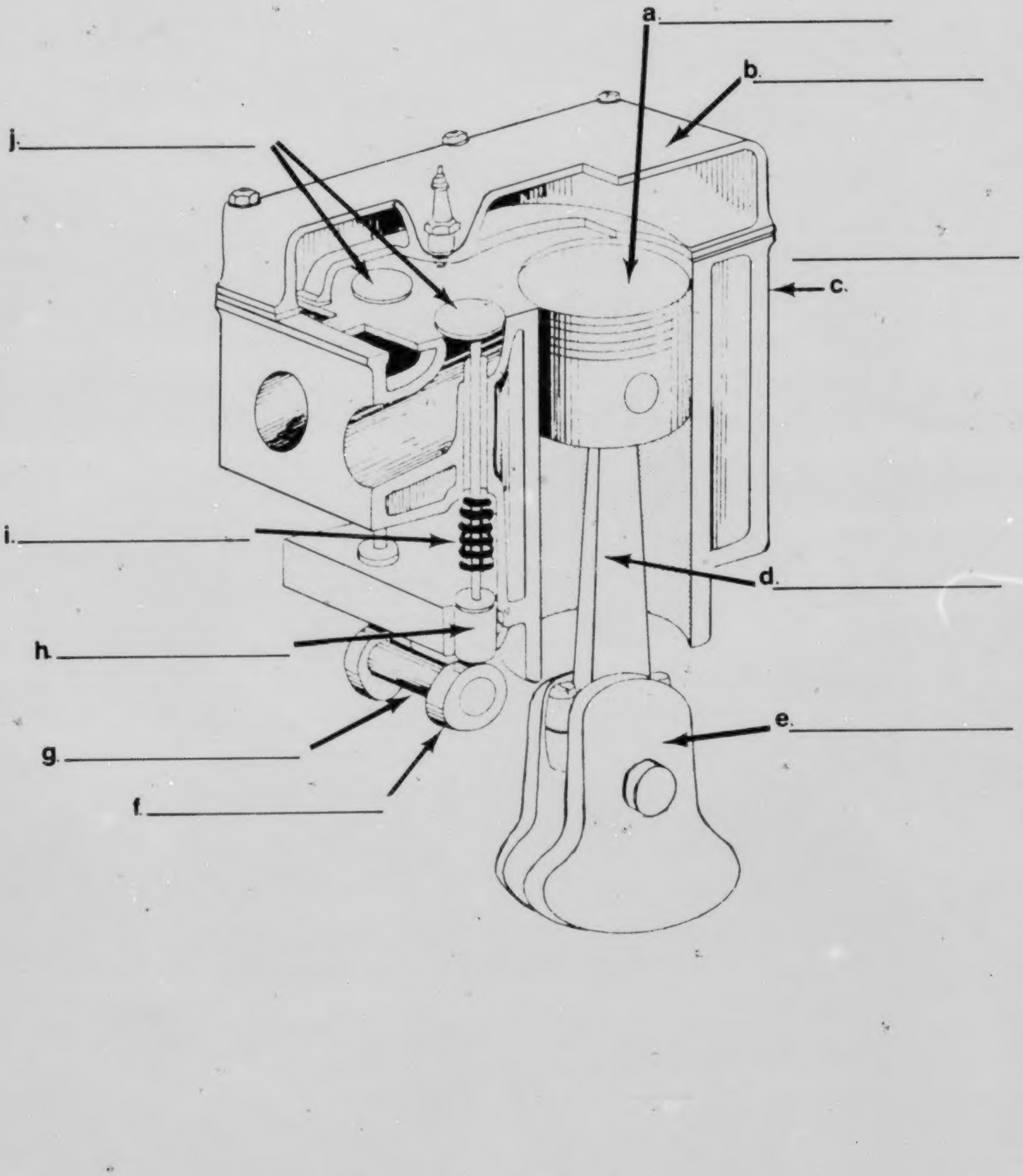
______k. Upward piston movement which expels burnt gases from cylinder

______l. Downward piston movement caused by spark ignition of compressed fuel-air mixture

______m. Engine component which opens to allow fuel-air mixture to enter cylinder during intake stroke

1. Exhaust valve
2. Power stroke
3. Valve seat
4. Camshaft
5. Intake stroke
6. Cam lobe
7. Valve
8. Valve spring
9. Intake valve
10. Overlap
11. Compression stroke
12. Exhaust stroke
13. Valve lifter or tappet

2. Identify the components of a four-stroke cycle engine.


a. ____________
b. ____________
c. ____________
d. ____________
e. ____________
f. ____________
g. ____________
h. ____________
i. ____________
j. ____________

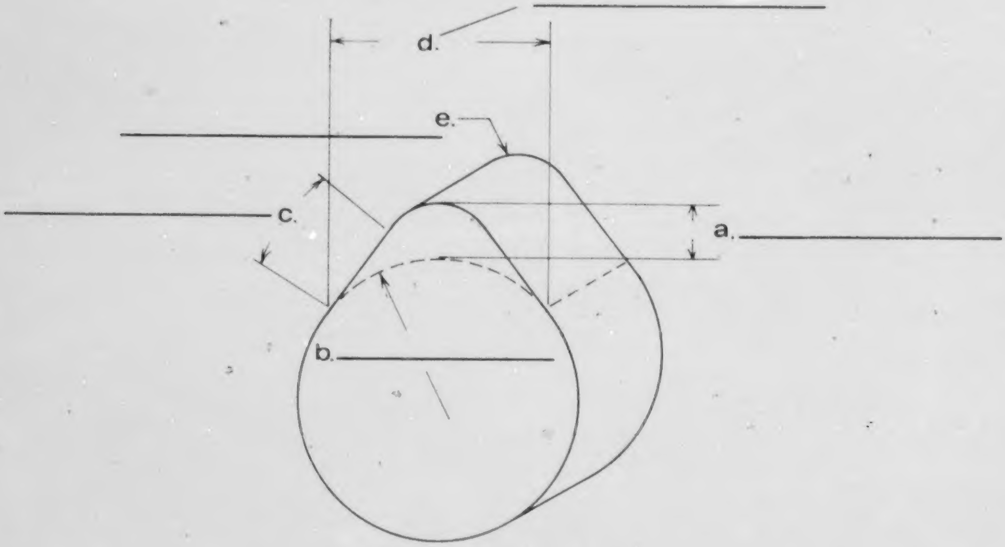
3. Discuss the operation of a four-stroke cycle engine.

4. List two factors that determine the firing order of a multi-cylinder engine.

   a.

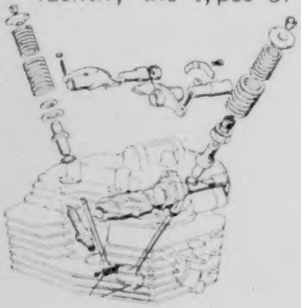
   b.

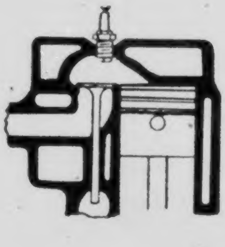
5. Identify the parts of a camshaft lobe.

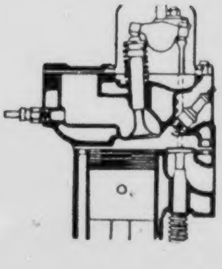


6. Discuss valve timing and overlap.

7. Identify the types of valve arrangements.



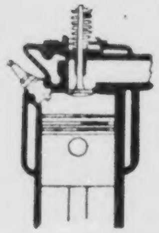




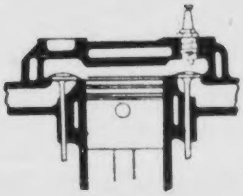
a. ______

b. ______

c. ______



d. ____________________



e. ____________________

PRINCIPLES OF OPERATION - FOUR-STROKE CYCLE
UNIT III

ANSWERS TO TEST

1. a. 8
   b. 7
   c. 6
   d. 10
   e. 11
   f. 5
   g. 13
   h. 3
   i. 4
   j. 1
   k. 12
   l. 2
   m. 9

2. a. Piston
   b. Cylinder head
   c. Cylinder block
   d. Connecting rod
   e. Crankshaft
   f. Cam lobe
   g. Camshaft
   h. Valve lifter
   i. Valve spring
   j. Valves

3. Discussion should include:

   a. Intake stroke

      1) Cycle starts with piston at uppermost position in cylinder (TDC) with intake valve open and exhaust valve closed

      2) As the piston moves down the cylinder, it draws air-fuel mixture into the cylinder from the carburetor

      3) When the piston reaches the bottom of the cylinder (BDC), the intake valve closes

b. Compression stroke

  1) Air-fuel mixture is compressed tightly as the piston moves up the cylinder

  2) Compression of the fuel creates heat which prepares the fuel for instant ignition

c. Power stroke

  1) As the piston reaches the top of the cylinder on compression stroke, a spark from the ignition system ignites the air-fuel mixture

  2) Burning gases expand very rapidly and force the piston down the cylinder

d. Exhaust stroke

  1) As the piston reaches the bottom of the cylinder on power stroke, the exhaust valve opens

  2) Piston travels up the cylinder, forcing the burned gases out of the cylinder into the exhaust manifold

4. a. Design of the crankshaft

   b. Location of the cams on the camshaft

5. a. Lift

   b. Base circle

   c. Flank

   d. Lobe

   e. Nose

6. Discussion should include:

   a. Intake valve--Opens approximately 15 degrees before the intake stroke begins and remains open through intake stroke and 20 degrees into compression stroke

   b. Exhaust valve--Opens approximately 40 degrees before the exhaust stroke begins and remains open through exhaust stroke and 20 degrees into the intake stroke

   c. Valve overlap--Both intake and exhaust valves are partially open; the intake valve is starting to open while the exhaust valve is not yet closed

7. a. Overhead cam
   b. L-Head
   c. F-Head
   d. I-Head
   e. T-Head

PRINCIPLES OF OPERATION - TWO-STROKE CYCLE
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the components and discuss the operation of a two-stroke cycle engine. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with two-stroke cycle engines to the correct definitions.
2. Identify the components of a basic two-stroke cycle engine.
3. Discuss the operation of a two-stroke cycle engine.
4. Identify the types of valves that may be used in two-stroke cycle engines.
5. Select the factors which determine timing on a two-stroke cycle engine.
6. Distinguish between cross-scavenged and loop-scavenged two-stroke cycle engines.
7. List features which make a two-stroke cycle engine preferable for many applications.
8. Discuss the importance of correct exhaust system design on a two-stroke cycle engine.

PRINCIPLES OF OPERATION - TWO-STROKE CYCLE
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate location of components on a live engine.

   G. Disassemble an engine so that students can identify individual components.

   H. Provide examples of reed and rotary valves.

   I. Provide examples of cross-scavenged and loop-scavenged engines.

   J. Demonstrate the use of correct and incorrect exhaust system designs.

   K. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Locate components on a live engine.

   D. Observe different types of valves.

   E. Observe cross-scavenged and loop-scavenged engines.

   F. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

C. Transparency masters

1. TM 1--Two-Stroke Cycle Engine
2. TM 2--Operation of the Two-Stroke Cycle Engine
3. TM 3--Reed Valves
4. TM 4--Rotary Valves and Piston Port
5. TM 5--Timing Essentials
6. TM 6--Design Variations
7. TM 7--Exhaust System Design

D. Test

E. Answers to test

II. References:

A. Roth, Alfred C. and Ronald J. Baird. *Small Gas Engines.* South Holland, Illinois: The Goodheart-Wilcox Company, Inc., 1975.

B. *Small Engine Service Manual*, 11th Edition. Kansas City, Missouri: Technical Publications Division, Intertec Publishing Corporation, 1976.

PRINCIPLES OF OPERATION - TWO-STROKE CYCLE
UNIT IV

INFORMATION SHEET

I. Terms and definitions

   A. Ports--Openings in the cylinder wall which allows the fuel-air mixture to enter and the exhaust to escape

   B. Transfer port--Passage which allows movement of the fuel-air mixture from the crankcase into the combustion chamber

   C. Rotary valve--Flat circular plate with a section of the plate cut away that operates between the carburetor and the crankcase

   D. Reed valve--(leaf valve)--One way valve made of spring steel which allows the fuel-air mixture to flow in one direction only

   E. Crankcase pressure--Pressure built up in the crankcase by the downward movement of the piston

   (NOTE: This causes the fuel-air mixture to move into the combustion chamber.)

   F. Crankcase vacuum--Negative crankcase pressure created when piston moves upward in cylinder

   G. Expansion chamber--Exhaust system specially designed to produce maximum horsepower at a specific RPM range

II. Components of a basic two-stroke cycle engine (Transparency 1)

   (NOTE: The two-stroke cycle engine may be referred to as a two cycle engine.)

   A. Cylinder

   B. Piston

   C. Crankshaft

   D. Connecting rod

   E. Cylinder head

   F. Crankcase

   (NOTE: The cylinder and cylinder head may be made as one piece.)

III. Operation of two-stroke cycle engine (Transparency 2)

   A. Piston moves up in cylinder drawing fuel-air mixture into crankcase

INFORMATION SHEET

- B. Piston moves down cylinder, pressurizing mixture in crankcase
- C. Piston moves past transfer port allowing pressurized mixture to move into combustion chamber
- D. Piston moves up in cylinder again
    - 1. Compresses fuel-air mixture
    - 2. Draws more fuel-air mixture into crankcase
- E. Spark plug fires compressed mixture
- F. Combustion moves piston back down cylinder
    - 1. Piston uncovers exhaust port as it nears bottom of stroke allowing exhaust to escape
    - 2. Piston uncovers transfer port as it moves nearer bottom of stroke allowing fresh charge of fuel-air to enter combustion chamber
- G. Piston starts back up cylinder closing both transfer and exhaust ports

IV. Valves used in two-stroke cycle engines (Transparencies 3 and 4)

- A. Reed valve
- B. Rotary valve
- C. Piston port

V. Factors which determine timing on two-stroke cycle engines (Transparency 5)

- A. Location of intake port
- B. Location of transfer port
- C. Location of exhaust port

VI. Design variations (Transparency 6)

- A. Cross-scavenged
    - 1. Special piston shape acts as baffle
    - 2. Deflected fuel-air charge moves upward in cylinder
    - 3. Charge prevented from going straight out exhaust port

INFORMATION SHEET

B. Loop-scavenged

1. Transfer ports shaped and located so that incoming fuel-air mixture swirls

2. Controlled flow of gas helps exhaust out and new charge to enter

VII. Features which make a two-stroke cycle engine preferable for many applications

A. Simple design

B. Light weight

C. Smaller size for equivalent horsepower

D. Adequate lubrication in any position

E. Continuous supply of new, clean oil to all moving parts

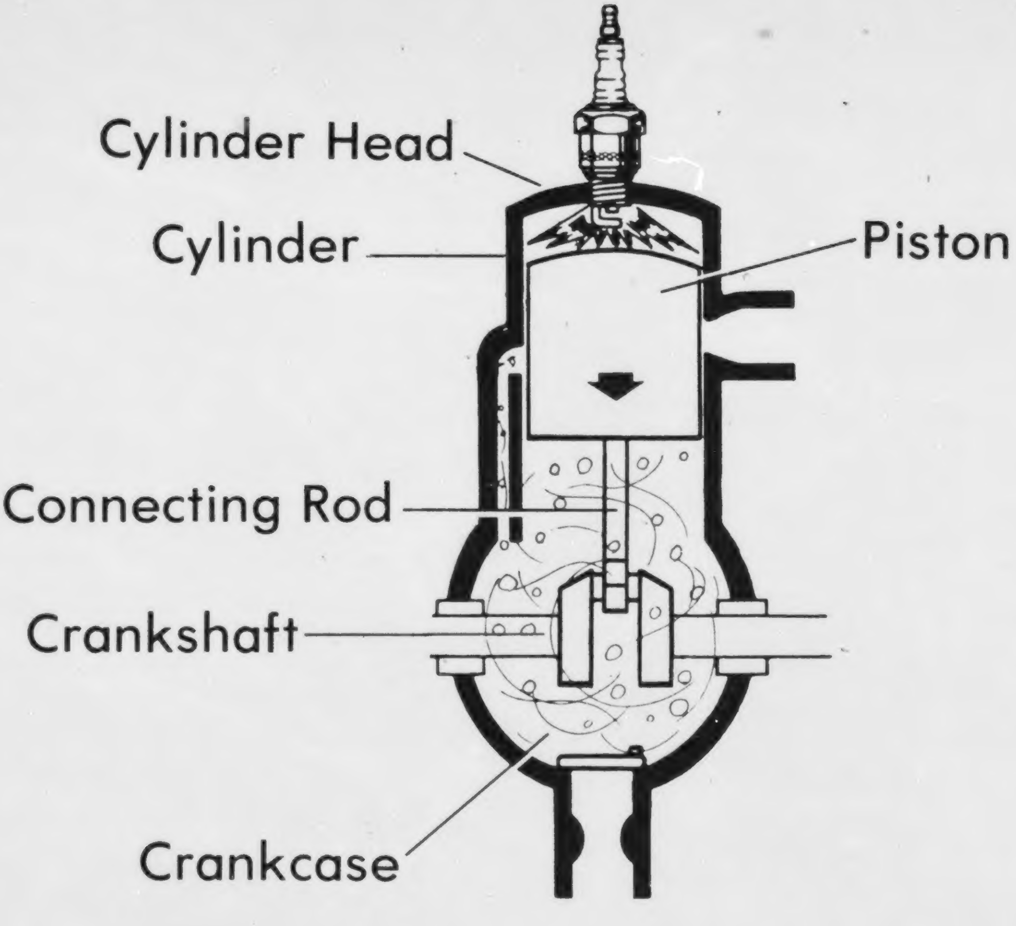
VIII. Correct exhaust system design (Transparency 7)

A. Scavenges all exhaust from combustion chamber

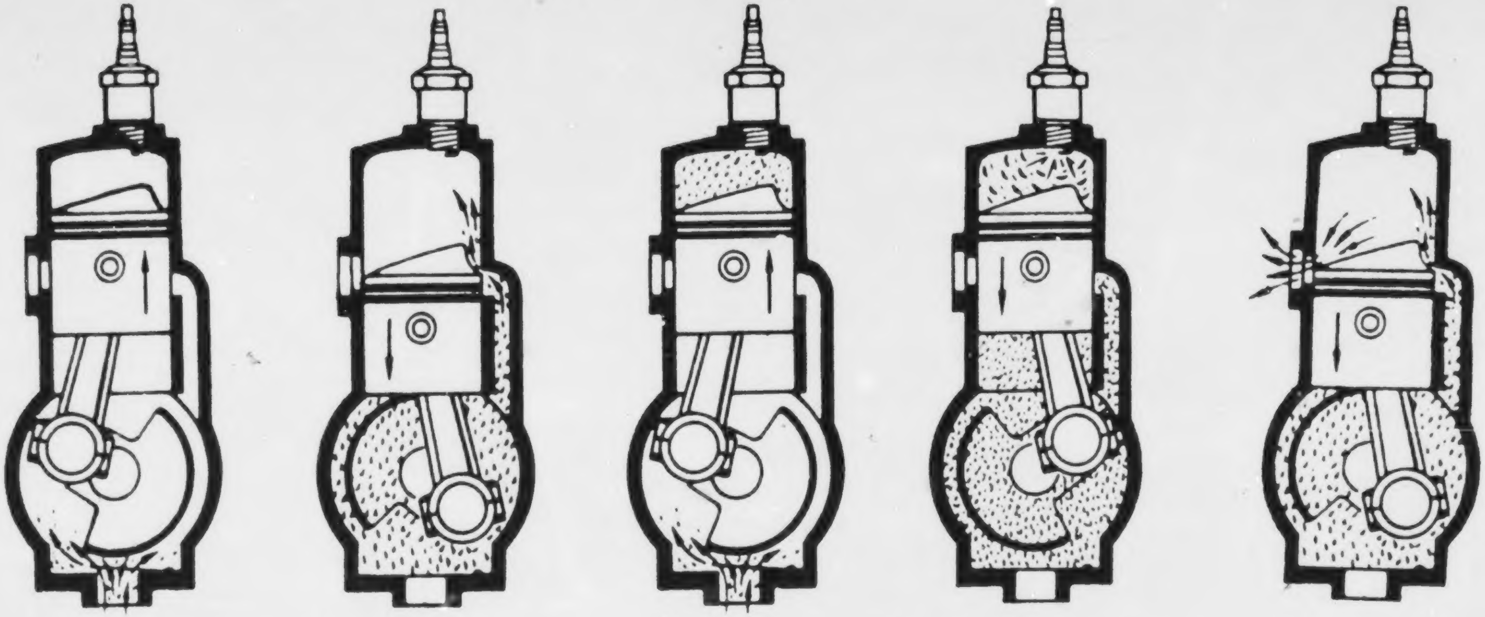
B. Allows new fuel charge to move into combustion chamber rapidly

C. Sound waves hold fuel charge momentarily while exhaust port is open

TWO-STROKE CYCLE ENGINE


Cylinder Head
Cylinder
Piston
Connecting Rod
Crankshaft
Crankcase

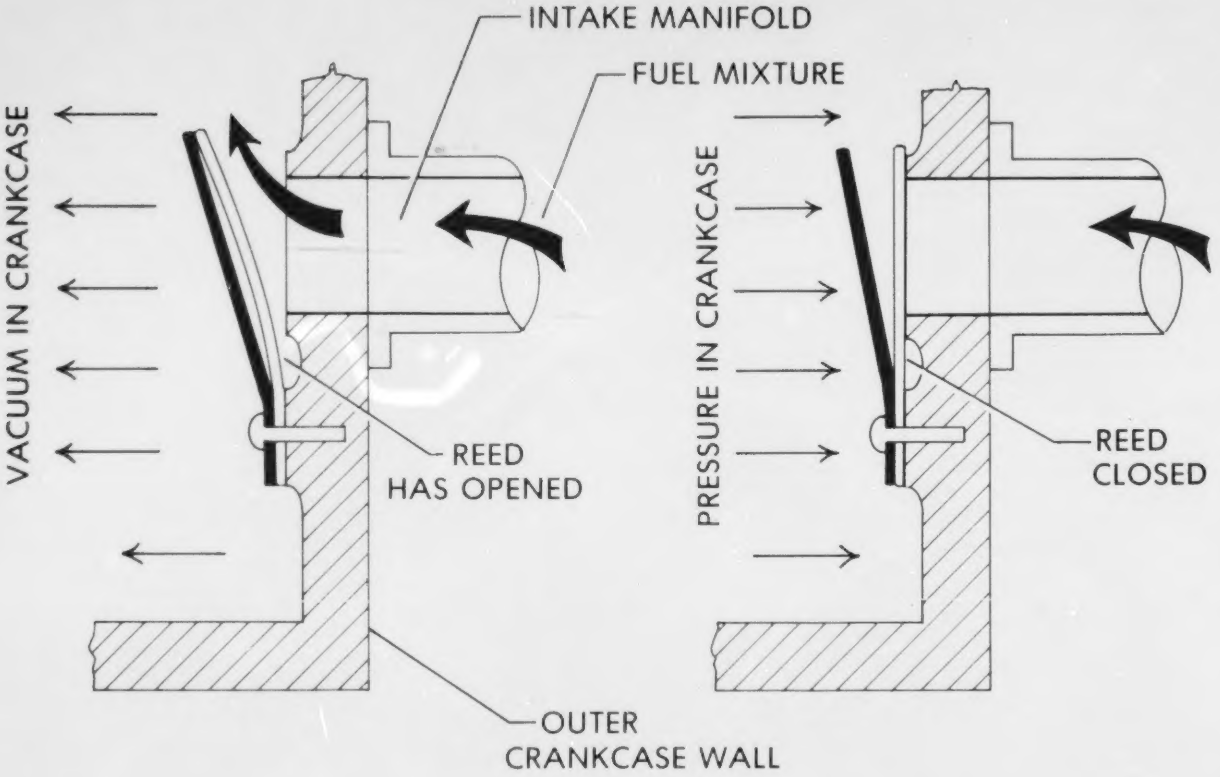
OPERATION OF THE TWO-STROKE CYCLE ENGINE

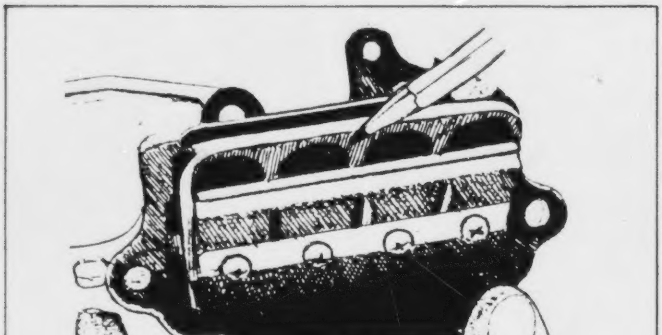

INTAKE
POWER
COMPRESSION
EXHAUST

TM - 2

SE - 133-B

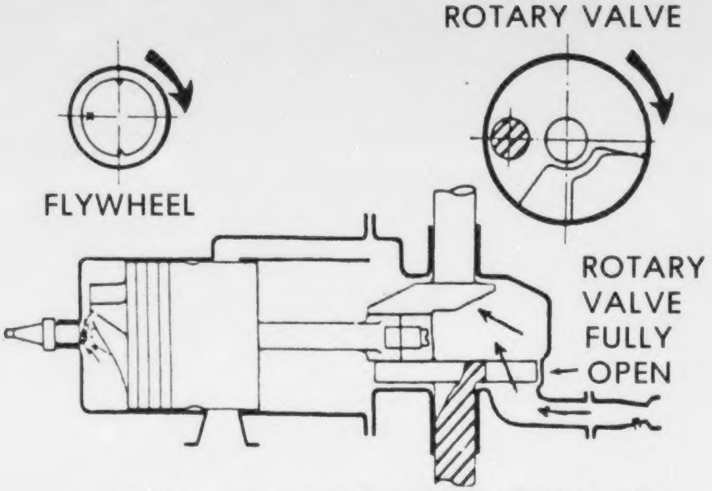
REED VALVES


INTAKE MANIFOLD
FUEL MIXTURE
VACUUM IN CRANKCASE
REED HAS OPENED
PRESSURE IN CRANKCASE
REED CLOSED
OUTER CRANKCASE WALL

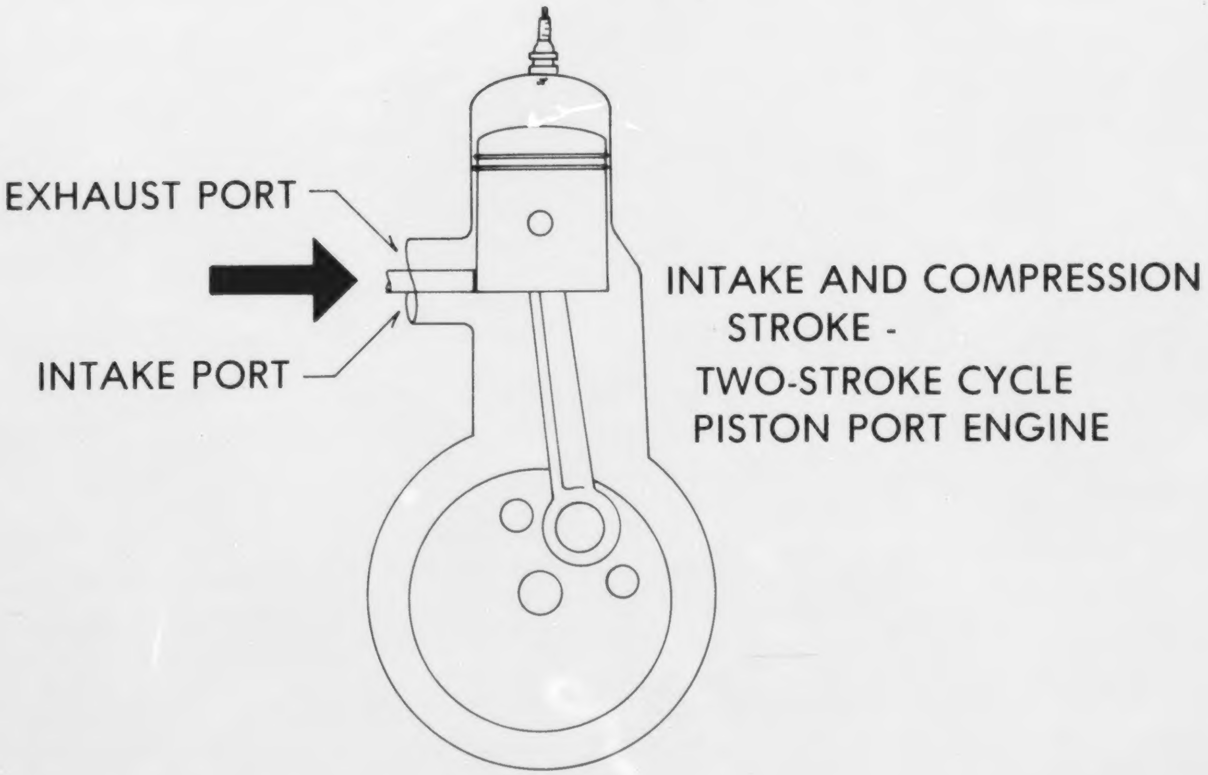


FRONTAL VIEW OF REED VALVE

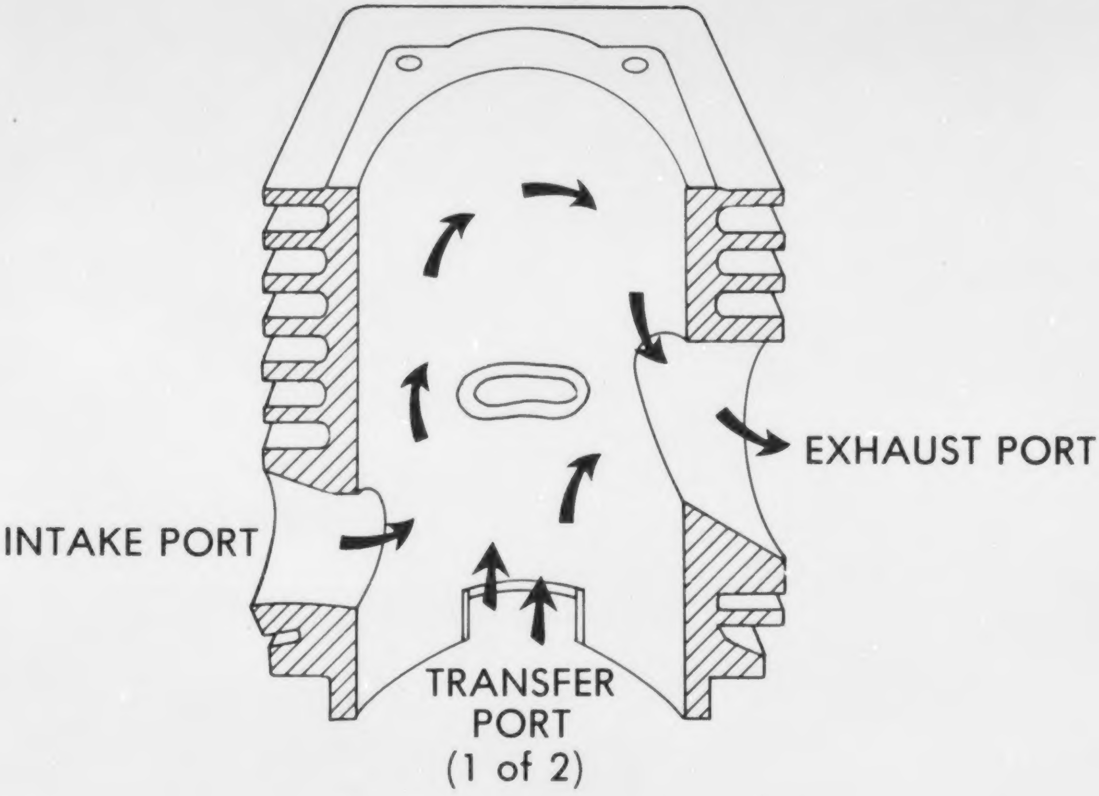
ROTARY VALVES AND PISTON PORT

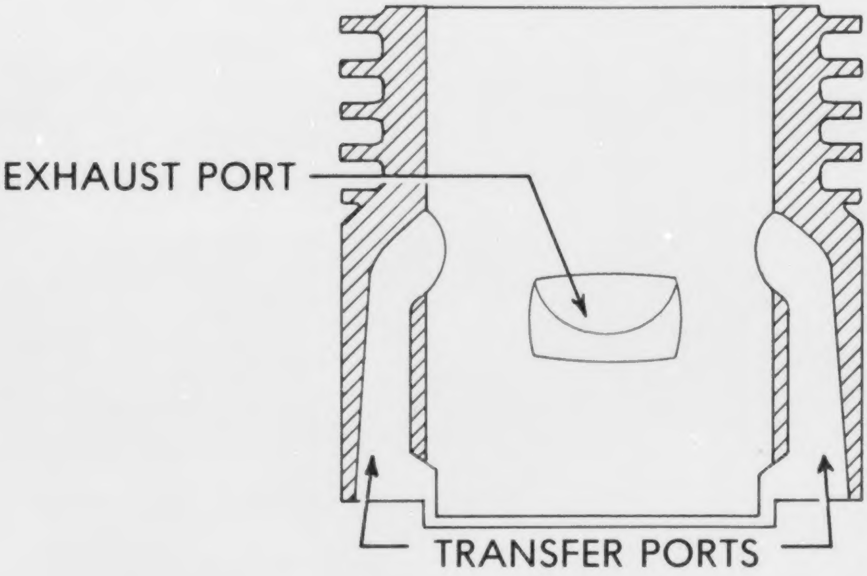

ROTARY VALVE
FLYWHEEL
ROTARY
VALVE
FULLY
OPEN

FIRING CHARGE IN CYLINDER

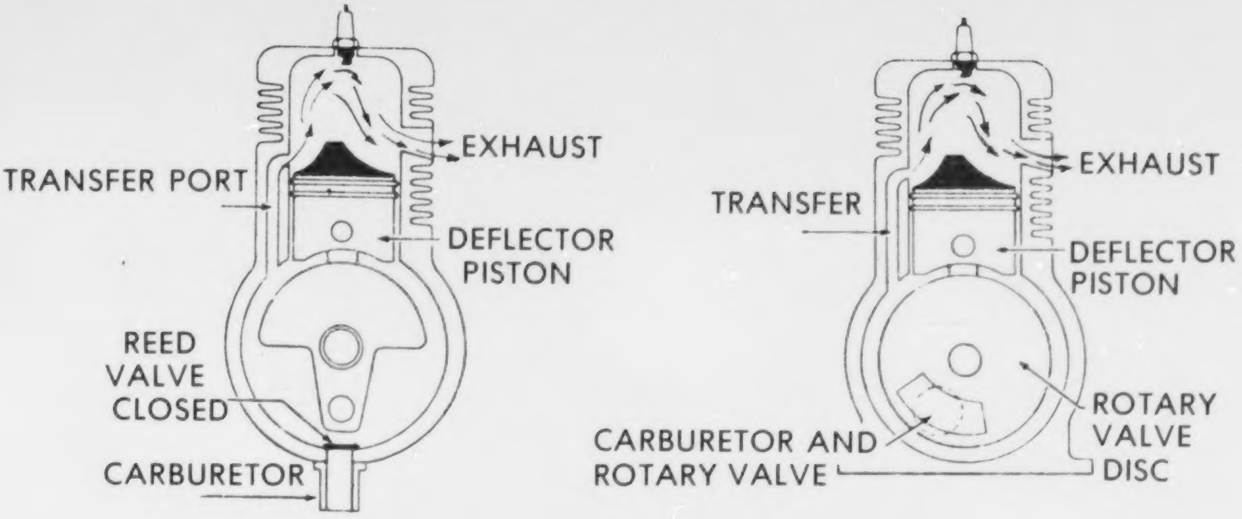

EXHAUST PORT
INTAKE PORT
INTAKE AND COMPRESSION
STROKE -
TWO-STROKE CYCLE
PISTON PORT ENGINE

TIMING ESSENTIALS

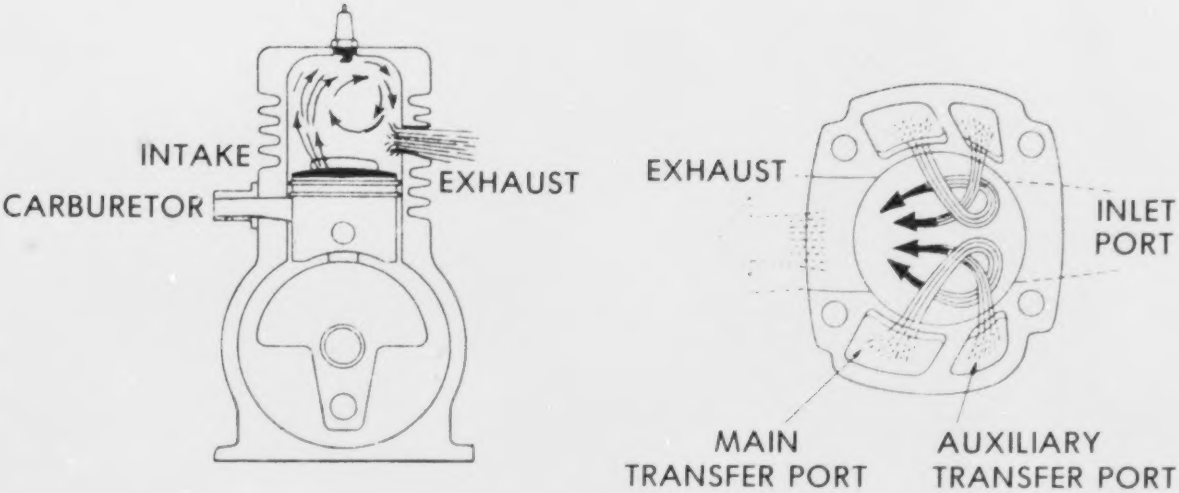

EXHAUST PORT
INTAKE PORT
TRANSFER PORT
(1 of 2)


EXHAUST PORT
TRANSFER PORTS

DESIGN VARIATIONS


TRANSFER PORT
EXHAUST
DEFLECTOR PISTON
REED VALVE CLOSED
CARBURETOR
TRANSFER
EXHAUST
DEFLECTOR PISTON
ROTARY VALVE DISC
CARBURETOR AND ROTARY VALVE

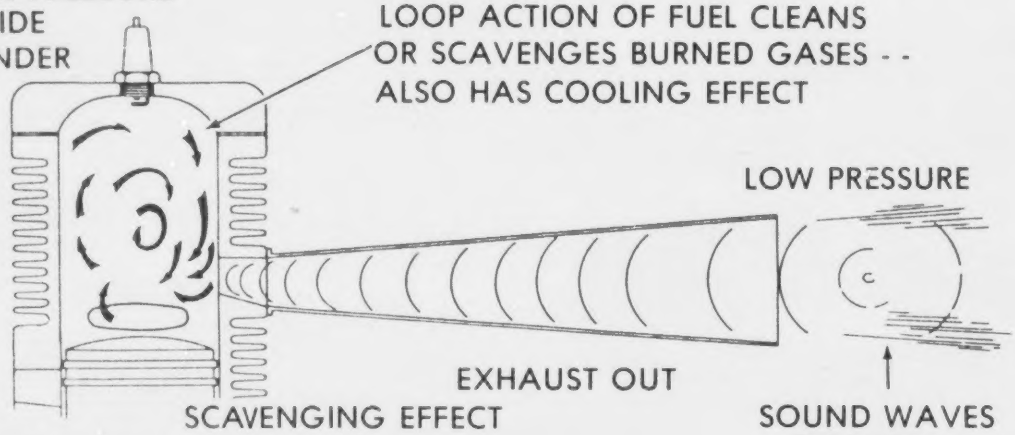
CROSS SCAVENGED


INTAKE
CARBURETOR
EXHAUST
EXHAUST
INLET PORT
MAIN TRANSFER PORT
AUXILIARY TRANSFER PORT

LOOP SCAVENGED

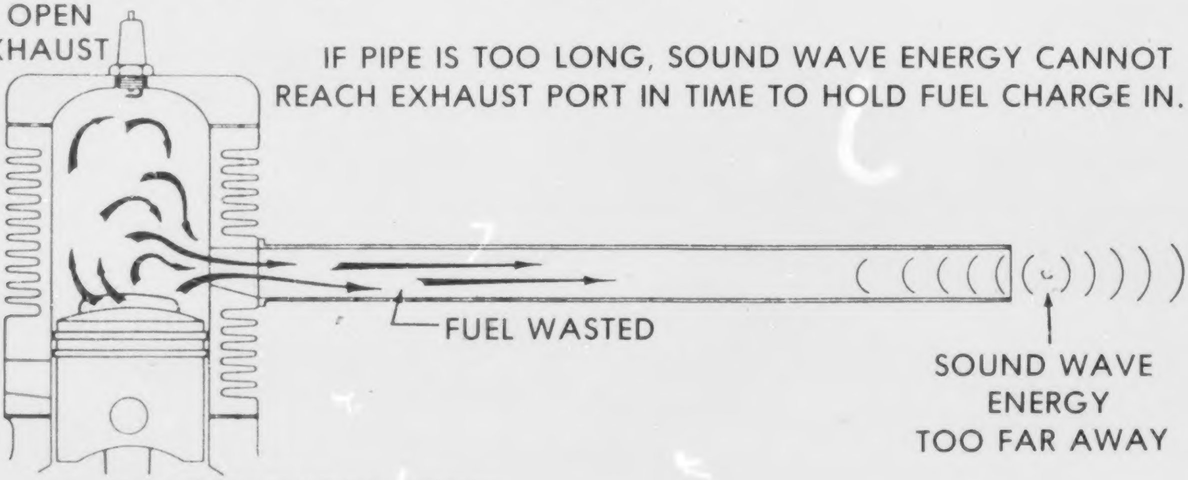
EXHAUST SYSTEM DESIGN

CORRECT


HIGHER PRESSURE
INSIDE
CYLINDER
LOOP ACTION OF FUEL CLEANS
OR SCAVENGES BURNED GASES - -
ALSO HAS COOLING EFFECT
LOW PRESSURE
EXHAUST OUT
SCAVENGING EFFECT
SOUND WAVES
CREATED
BY EXHAUST
TRANSFER PORT
PULLS NEW FUEL
CHARGE IN FROM
CRANKCASE

REFLECTED SOUND WAVES
HOLD FUEL CHARGE IN CYLINDER

INCORRECT


WITHOUT BACK PRESSURE
FUEL CAN GO RIGHT OUT
OPEN
EXHAUST
IF PIPE IS TOO LONG, SOUND WAVE ENERGY CANNOT
REACH EXHAUST PORT IN TIME TO HOLD FUEL CHARGE IN.
FUEL WASTED
SOUND WAVE
ENERGY
TOO FAR AWAY
OVERSCAVENGED EFFECT
(PIPE TOO LONG)

OVERSCAVENGING FROM WRONG LENGTH OF EXHAUST PIPE

PRINCIPLES OF OPERATION - TWO-STROKE CYCLE
UNIT IV

NAME ______________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Pressure built up in the crankcase by the downward movement of the piston

_____b. One way valve made of spring steel which allows the fuel-air mixture to flow in one direction only

_____c. Openings in the cylinder wall which allows the fuel-air mixture to enter and the exhaust to escape

_____d. Passage which allows movement of the fuel-air mixture from the crankcase into the combustion chamber

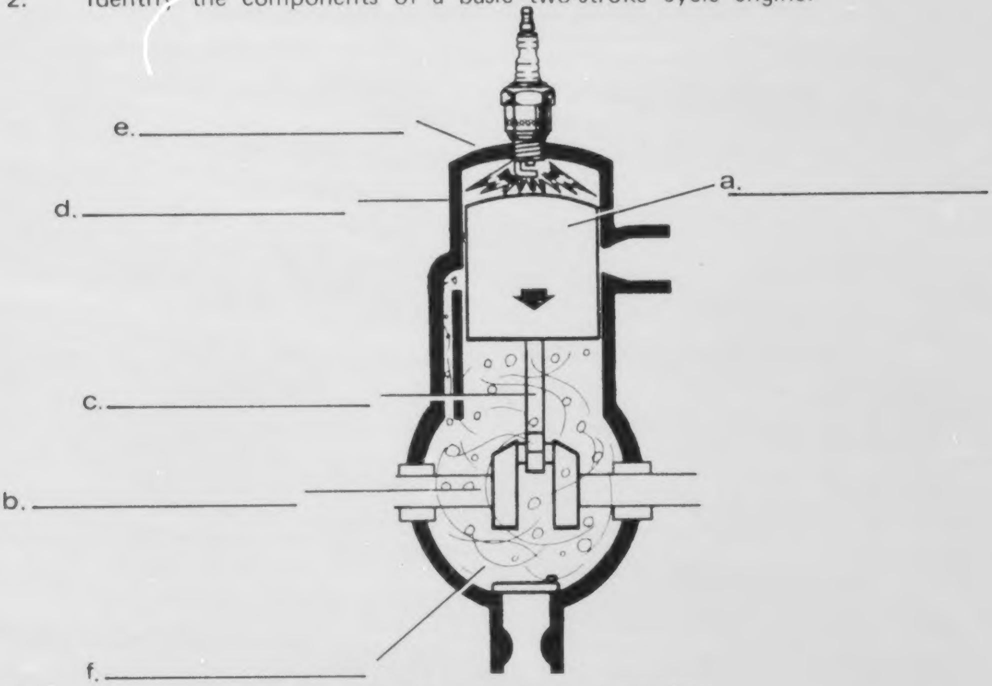
_____e. Flat circular plate with a section of the plate cut away that operates between the carburetor and the crankcase

_____f. Exhaust system specially designed to produce maximum horsepower at a specific RPM range

_____g. Negative crankcase pressure created when piston moves upward in cylinder

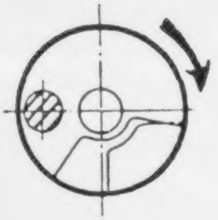
1. Transfer port
2. Reed valve (leaf valve)
3. Ports
4. Expansion chamber
5. Crankcase pressure
6. Crankcase vacuum
7. Rotary valve

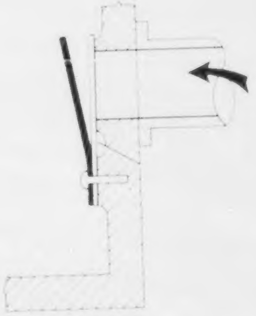
2. Identify the components of a basic two-stroke cycle engine.

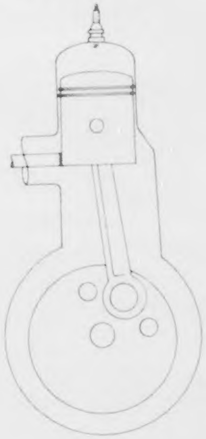


3. Discuss the operation of a two-stroke cycle engine.

4. Identify the types of valves that may be used in two-stroke cycle engines.







a. ____________ b. ____________ c. ____________

5. Select the factors which determine timing on a two-stroke cycle engine.

_____a. Location of transfer port

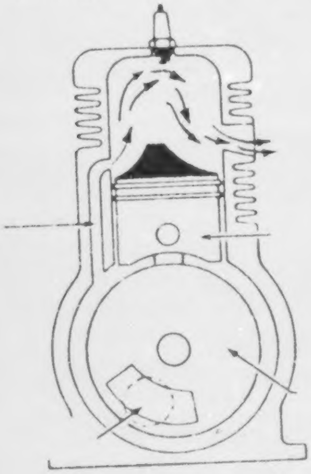
_____b. Location of cam lobe positions

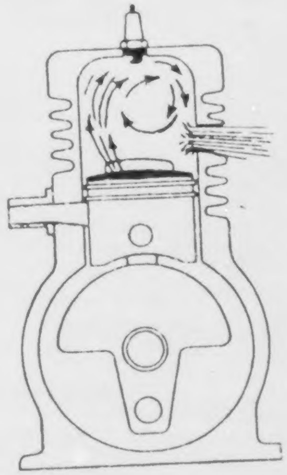
_____c. Location of exhaust valve

_____d. Location of intake port

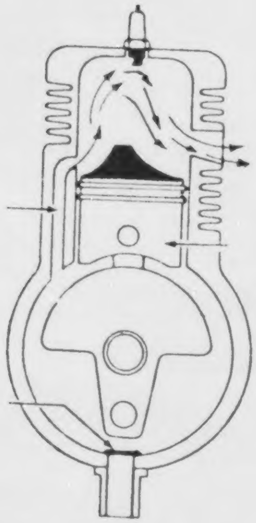
_____e. Location of exhaust port

6. Distinguish between cross-scavenged and loop-scavenged two-stroke cycle engines by writing the name of each in the appropriate blank.

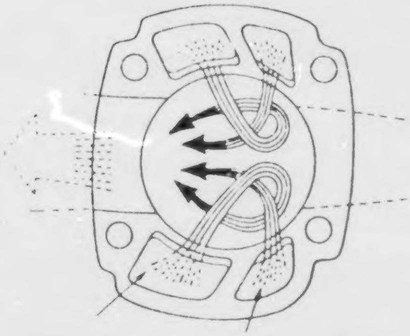




a. ____________ b. ____________



c. ______________________



d. ______________________

7. List three features which make a two-stroke cycle engine preferable for many applications.

   a.

   b.

   c.

8. Discuss the importance of correct exhaust system design on a two-stroke cycle engine.

PRINCIPLES OF OPERATION - TWO-STROKE CYCLE
UNIT IV

ANSWERS TO TEST

1. a. 5
   b. 2
   c. 3
   d. 1
   e. 7
   f. 4
   g. 6

2. a. Piston
   b. Crankshaft
   c. Connecting rod
   d. Cylinder
   e. Cylinder head
   f. Crankcase

3. Discussion should include:
   a. Piston moves up in cylinder drawing fuel-air mixture into crankcase
   b. Piston moves down cylinder, pressurizing mixture in crankcase
   c. Piston moves past transfer port allowing pressurized mixture to move into combustion chamber
   d. Piston moves up in cylinder again
      1. Compresses fuel-air mixture
      2. Draws more fuel-air mixture into crankcase
   e. Spark plug fires compressed mixture
   f. Combustion moves piston back down cylinder
      1. Piston uncovers exhaust port as it nears bottom of stroke allowing exhaust to escape
      2. Piston uncovers transfer port as it moves nearer bottom of stroke allowing fresh charge of fuel-air to enter combustion chamber
   g. Piston starts back up cylinder closing both transfer and exhaust ports

4. a. Rotary
   b. Reed
   c. Piston port

5. a, d, e

6. a. Cross-scavenged
   b. Loop-scavenged
   c. Cross-scavenged
   d. Loop-scavenged

7. Any three of the following:
   a. Simple design
   b. Light weight
   c. Smaller size for equivalent horsepower
   d. Adequate lubrication in any position
   e. Continuous supply of new, clean oil to all moving parts

8. Discussion should include:
   a. Scavenges all exhaust from combustion chamber
   b. Allows new fuel charge to move into combustion chamber rapidly
   c. Sound waves hold fuel charge momentarily while exhaust port is open

BASIC ELECTRICITY
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss types of current and the relationship between electricity and magnetism. The student should also be able to identify types of electrical circuits and demonstrate the ability to solve problems using ohm's law. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with basic electricity to the correct definitions.
2. Select sources of electricity related to small engine repair.
3. Select parts of a basic circuit.
4. Distinguish between good conductors and insulators of electricity.
5. Discuss direct and alternating current.
6. Explain why copper is widely used as a conductor.
7. Match the basic circuit terms to their units of measure.
8. Match the basic electrical schematic symbols to the correct names.
9. Match the letter designations used in ohm's law to the correct terms.
10. Draw ohm's law formula in triangle expression.
11. State ohm's law in letter formula for calculating voltage, current, and resistance.
12. Identify three types of electrical circuits.
13. List three rules for series circuits.
14. List three rules for parallel circuits.
15. Select factors effecting resistance in a conductor.

16. Select the characteristics of magnetism.
17. Explain two ways an iron bar may be magnetized.
18. Discuss the relationship between electricity and magnetism.
19. Select factors that determine the magnitude of induced voltage.
20. Select instruments used in checking electrical circuits.
21. Solve problems using ohm's law formula.

BASIC ELECTRICITY
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Dicuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Discuss electron theory to promote a basic understanding of electricity.

   G. Demonstrate magnetic lines of force by using iron filings and a conductor.

   H. Demonstrate the construction of a series and a parallel circuit.

   I. Give test.

II. Student

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment sheet.

   D. Participate in discussion of electron theory.

   E. Observe the construction of a series and a parallel circuit.

   F. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

C. Transparency masters

1. TM 1--Sources of Electricity
2. TM 2--Ohm's Law in Triangle Expression
3. TM 3--Ohm's Law in Letter Formula
4. TM 4--Types of Electrical Circuits
5. TM 5--Series Circuit Rules
6. TM 6--Parallel Circuit Rules
7. TM 7--Magnetism and Field of Force
8. TM 8--Electricity and Magnetism Relationship
9. TM 9--Measuring Instruments

D. Assignment Sheet #1--Solve Problems using Ohm's Law

E. Answers to assignment sheet

F. Test

G. Answers to test

II. References:

A. Parady, Harold W., and Turner, J. Howard. *Electric Energy*. Athens, Georgia: American Association for Vocational Instructional Materials, 1976.

B. *Small Engines, Volume 2.* Athens, Georgia: American Association for Vocational Instructional Materials, 1971.

BASIC ELECTRICITY
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Ampere--Unit of measure for electrical current

B. Ohm--Standard unit for measuring resistance to flow of an electrical current

C. Resistance--Opposition to current flow in a conductor

D. Voltage (emf)--Electromotive force which causes current to flow in an electrical circuit

E. Current--Flow of electrons through a conductor, measured in amperes

F. Conductor--Substance or body through which an electrical current readily flows

Examples: Copper, aluminum, silver

G. Insulator--Material which does not readily permit current flow

Examples: Rubber, glass, porcelain, air, oil, and plastic

H. Semiconductor--An element with an atomic configuration which makes it neither a good conductor nor insulator

I. Circuit--Continuous, unbroken path along a conductor through which electrical current can flow from a source, through various units and back to the source

J. Capacitor (condenser)--Device which stores an electrical charge

K. Ammeter--Instrument for measuring the flow of electrical current in amperes

L. Magnet--Body which has the property of attracting iron or other magnets

M. Magnetism--Power to attract other similar materials

N. Magnetic induction--Inducing voltage in a conductor that moves across a magnetic field

INFORMATION SHEET

II. Sources of electricity (Transparency 1)

  A. Chemical

    Example: Battery

  B. Magnetic

    Example: Generator

III. Parts of a basic circuit

  A. Voltage source

    Example: Battery

  B. Resistor

    Example: Light bulb

  C. Conductor

    Example: Copper wire

IV. Conductors and insulators of electricity

  A. Conductors

1. Silver

   (NOTE: Silver has the least resistance to current flow.)

2. Copper
3. Gold
4. Aluminum
5. Tungsten
6. Zinc
7. Brass
8. Platinum
9. Iron
10. Nickel

INFORMATION SHEET

11. Tin
12. Steel
13. Lead
14. Mercury
15. Nichrome

    (NOTE: Nichrome has the highest resistance to current flow.)

B. Insulators

1. Glass
2. Rubber
3. Plastic
4. Wood
5. Ceramic
6. Mica

V. Direct and alternating current

A. Direct current

1. Supplied by
    a. Generator
    b. Battery
        1) Dry cell
        2) Wet cell
2. Flows in one direction only
3. Abbreviated as DC

B. Alternating current

1. Supplied by an alternating current generator (alternator)
2. Flows in one direction then reverses and flows in the opposite direction
3. Abbreviated as AC

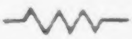
INFORMATION SHEET

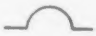
VI. Copper as a conductor--Copper is a good conductor because it has only one electron in outer ring and is comparitively cheaper than other metals which may have similar properties

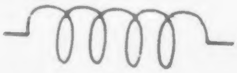
VII. Circuit terms and units of measure

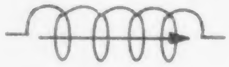
- A. Current--Amperes
- B. Voltage--Volts
- C. Resistance--Ohms

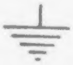
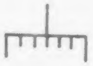
VIII. Basic electrical schematic symbols

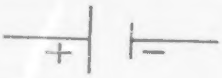
A. Resistance or load 

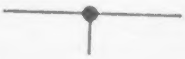
B. Ohms of resistance 

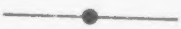
C. Coil 

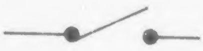
D. Solenoid 

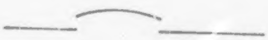
E. Ground  

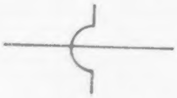
F. Battery 

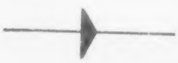
G. Connection 

H. Terminal 

I. Switch (open) 

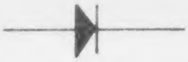
J. Circuit breaker 

K. Crossover 

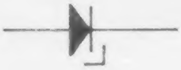
L. Direction of current 

INFORMATION SHEET

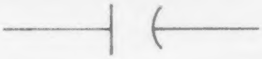
M. Diode (one-way)



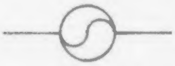
N. Zener diode



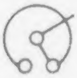
O. Capacitor



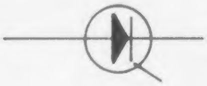
P. Fuse



Q. Rheostat



R. Silicon controlled rectifier (SCR)



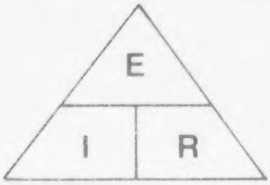
IX. Letters and terms

A. E–Electromotive force in volts

B. I–Intensity (current) in amps

C. R–Resistance in ohms

X. Ohm's law formula in triangle expression (Transparency 2)



(NOTE: E.I.R. formula reminder is the phrase "Even I Remember.")

XI. Ohm's law in letter formula (Transparency 3)

A. $E = I \times R$ or Volts = Amps x Ohms

B. $I = E/R$ or Amps = Volts ÷ Ohms

C. $R = E/I$ or Ohms = Volts ÷ Amps

XII. Types of electrical circuits (Transparency 4)

A. Series

B. Parallel

C. Series-parallel

INFORMATION SHEET

XIII. Rules for series circuits (Transparency 5)

- A. Current through each resistor is the same
- B. Voltage drops across each resistor will be different if the resistance values are different
- C. Sum of the voltage drops equals the source voltage

XIV. Rules for parallel circuit (Transparency 6)

- A. Voltage across each resistor is the same
- B. Current through each resistor will be different if the resistance values are different
- C. Sum of the separate currents equals the total circuit current

XV. Factors effecting resistance in a conductor

- A. Length
- B. Diameter
- C. Temperature
- D. Composition

XVI. Characteristics of magnetism (Transparency 7)

- A. Every magnet has a north and south pole
- B. Unlike poles attract and like poles repel
- C. Every magnet has a field of force surrounding it
- D. Magnetic materials are acted upon when located in a field of force
- E. An unmagnetized piece of iron can become a magnet by surrounding it with a current carrying coil

XVII. Magnetizing an iron bar

- A. Stroke an iron bar with another bar which has been magnetized
- B. Place an iron bar in a strong magnetic field

  (NOTE: Soft metals will not retain much magnetism when withdrawn from the magnetic field.)

INFORMATION SHEET

XVIII. Relationship between electricity and magnetism (Transparency 8)

A. Current passed through a wire (conductor) creates a magnetic field around the wire

B. Magnetic lines have direction and change direction when the current flow changes from one direction to another

(NOTE: The Right Hand Rule for a straight conductor can be used to find the direction of the lines of force around the wire. To apply the rule, grasp the wire with the thumb extended in the direction of conventional current flow (positive to negative); the fingers will then point in the direction in which the lines of force surround the conductor. These lines of force are always at right angles to the conductor.)

C. Conductor moving across a magnetic field will have a voltage induced in it

D. Voltage polarity and the current flow direction are determined by the direction of wire movement and direction of the lines of force

(NOTE: The conductor can move or the magnetic field can move.)

E. Ways to induce voltage by magnetic induction

1. Generated voltage by relative motion

   Examples: Generators and alternators

2. Self-induction voltage created by a change of current in the conductor

   Example: Primary of ignition coils

3. Mutual-induction which occurs when changing current in one coil induces voltage in a second coil

   Example: Two windings of ignition coils

F. Two conductors on an armature, carrying current in opposite directions, create a strong and weak field on opposite sides causing conductors to move apart or armature to rotate

(NOTE: The downward movement or rotation is caused by current flowing in the conductor. This is the principle by which a cranking motor operates.)

INFORMATION SHEET

XIX. Factors that determine the magnitude of induced voltage

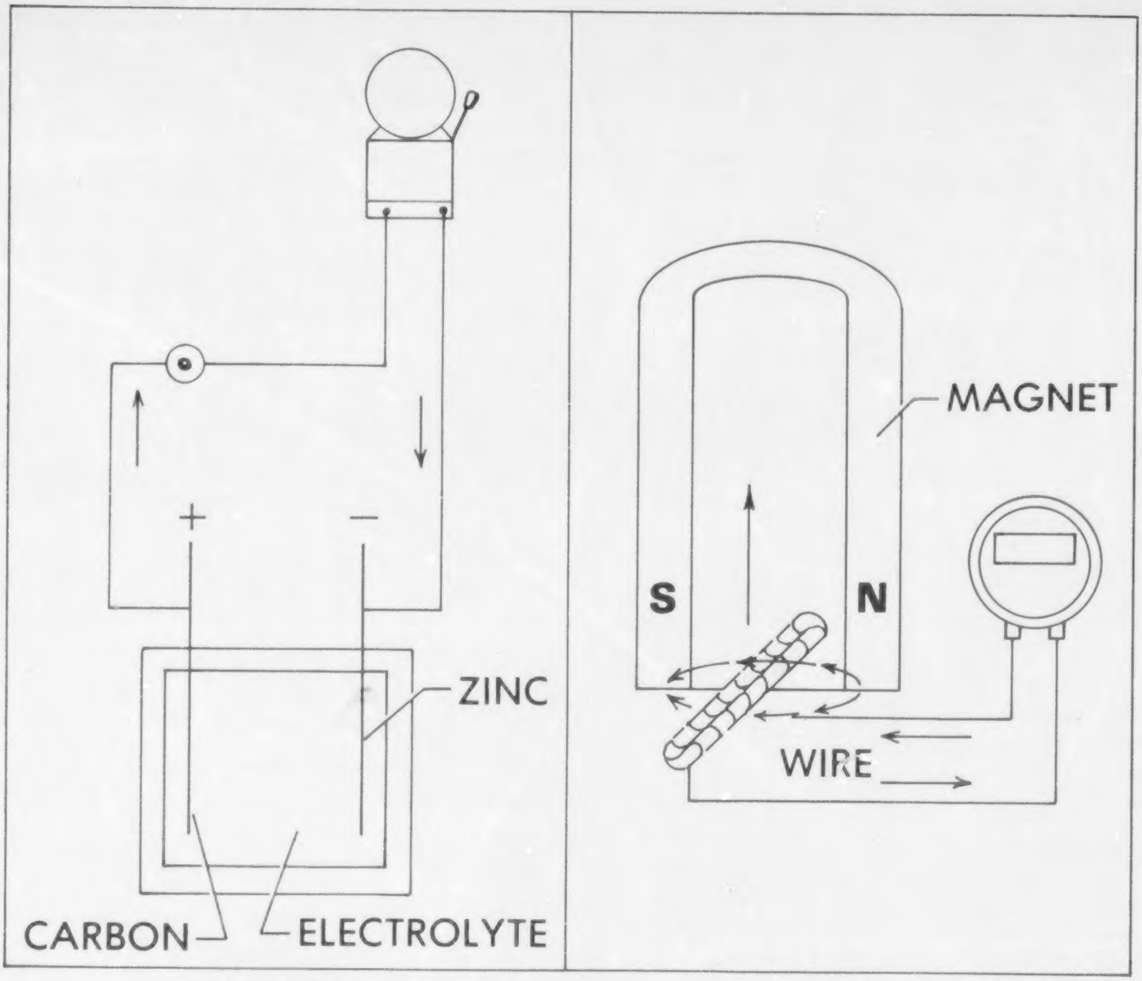
- A. Strength of the magnetic field
- B. Speed at which lines of force are cutting across the conductor
- C. Number of conductors that are cutting across the lines of force

XX. Instruments used in checking electrical circuits (Transparency 9)

- A. Ammeter
- B. Voltmeter
- C. Ohmmeter

(NOTE: Modern testers often combine the voltmeter, ammeter, and ohmmeter in one test unit, such as a battery-starter tester.)

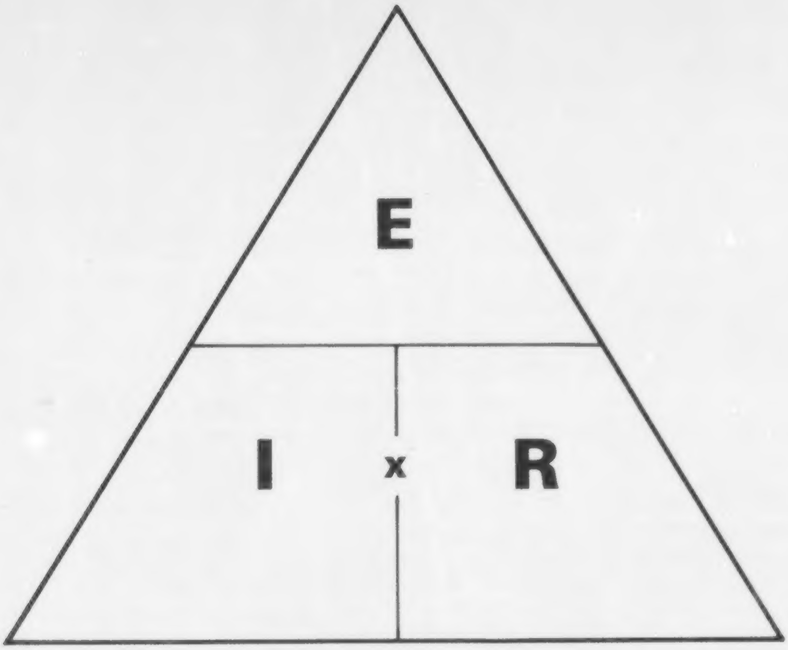
SOURCES OF ELECTRICITY


+
−
ZINC
CARBON
ELECTROLYTE
MAGNET
S
N
WIRE

CHEMICAL

MAGNETIC

OHM'S LAW IN TRIANGLE EXPRESSION



E = VOLTS I = AMPS R = RESISTANCE

NOTE: SOLVE FOR VOLTS, AMPS, OR RESISTANCE BY COVERING THE UNKNOWN

EXAMPLE:

COVER E, THEN E = I x R

COVER I, THEN I = E ÷ R

COVER R, THEN R = E ÷ I

OHM'S LAW IN LETTER FORMULA

ELECTROMOTIVE FORCE = CURRENT x RESISTANCE

$E = IR$ **VOLTS = AMPERES x OHMS**

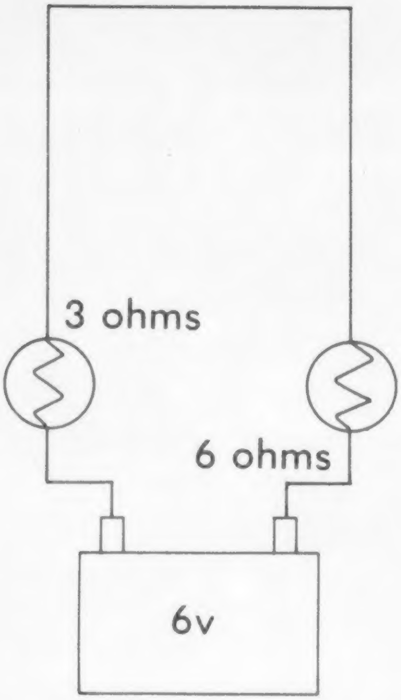
$$\text{CURRENT} = \frac{\text{ELECTROMOTIVE FORCE}}{\text{RESISTANCE}}$$

$$I = \frac{E}{R} \qquad \text{AMPERES} = \frac{\text{VOLTS}}{\text{OHMS}}$$

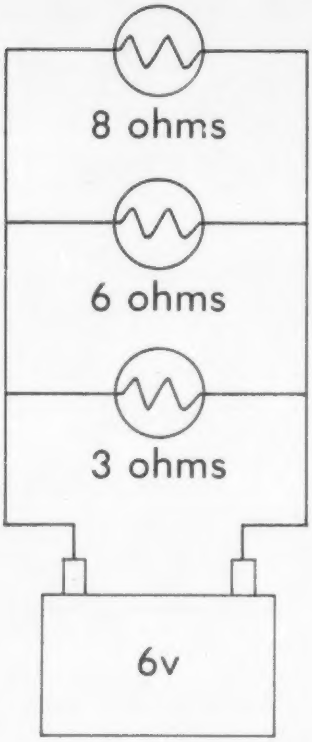
$$\text{RESISTANCE} = \frac{\text{ELECTROMOTIVE FORCE}}{\text{CURRENT}}$$

$$R = \frac{E}{I} \qquad \text{OHMS} = \frac{\text{VOLTS}}{\text{AMPERES}}$$

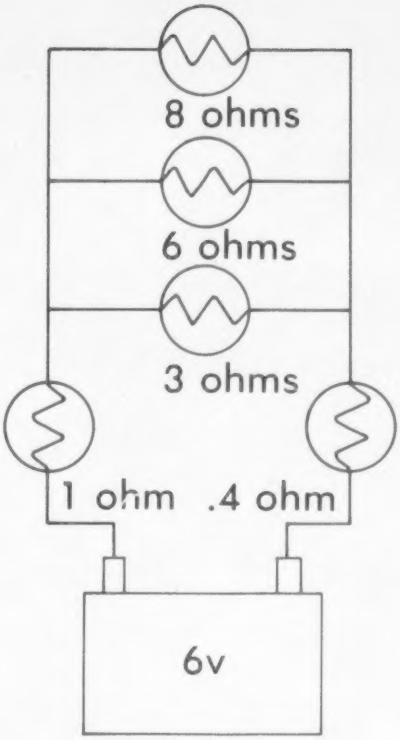
TYPES OF ELECTRICAL CIRCUITS


3 ohms
6 ohms
6v

SERIES CIRCUIT

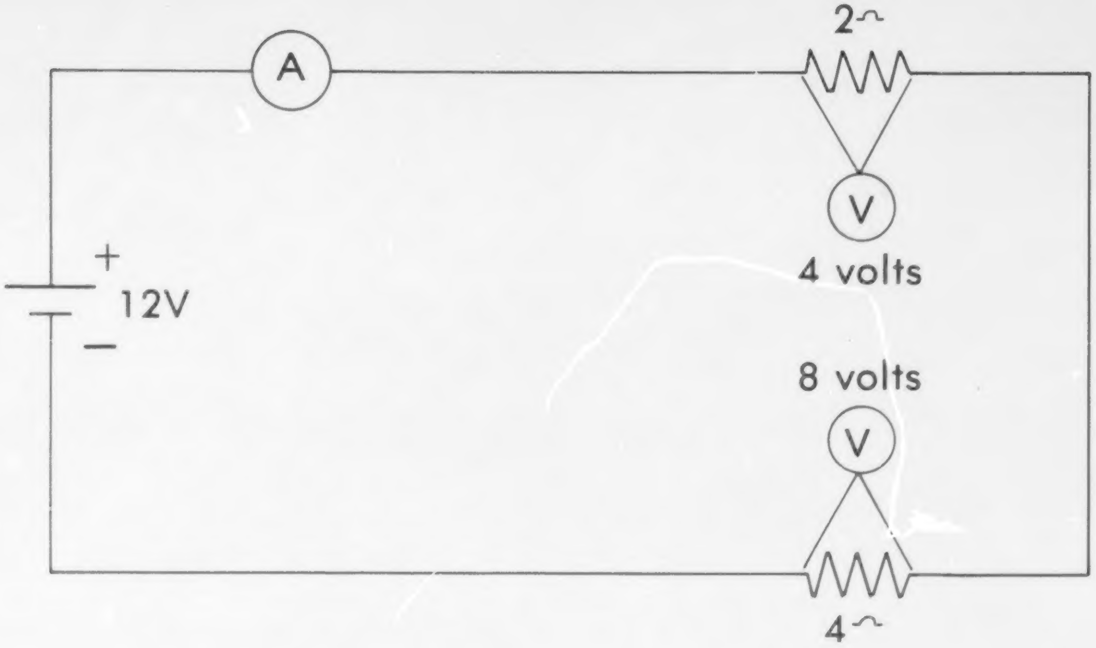

8 ohms
6 ohms
3 ohms
6v

PARALLEL CIRCUIT


8 ohms
6 ohms
3 ohms
1 ohm
.4 ohm
6v

SERIES PARALLEL CIRCUIT

SERIES CIRCUIT RULES


A
2Ω
V
4 volts
+
12V
−
8 volts
V
4Ω

A. $I = E/R$

$I = 12/6 = 2$ amp

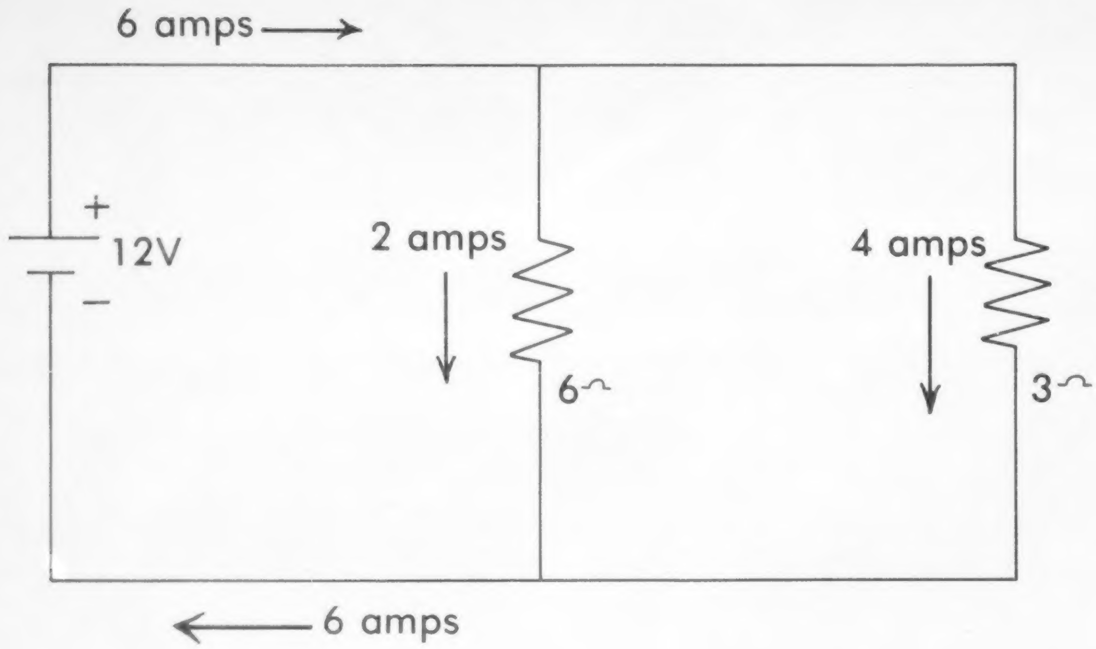
B. $E = IR$

$E = 2 \times 2 = 4$ volts

$E = 2 \times 4 = 8$ volts

C. $4 + 8 = 12$ volts

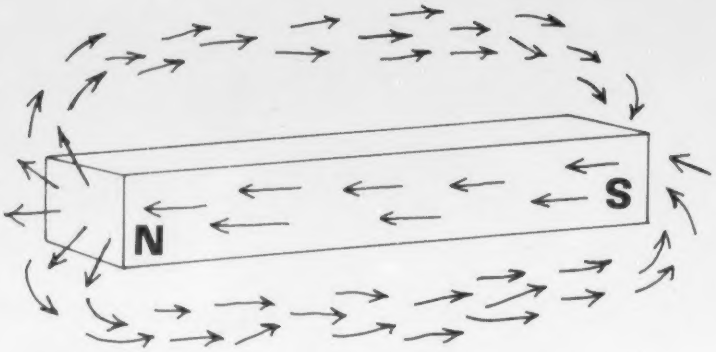
PARALLEL CIRCUIT RULES

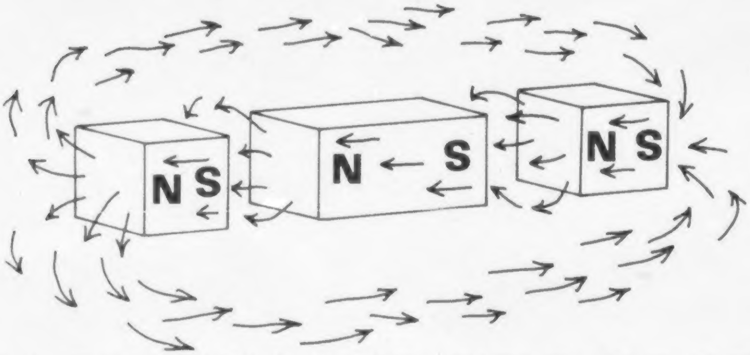

6 amps
+
12V
−
2 amps
6Ω
4 amps
3Ω
6 amps

A. Battery voltage across each resistor 12 volts

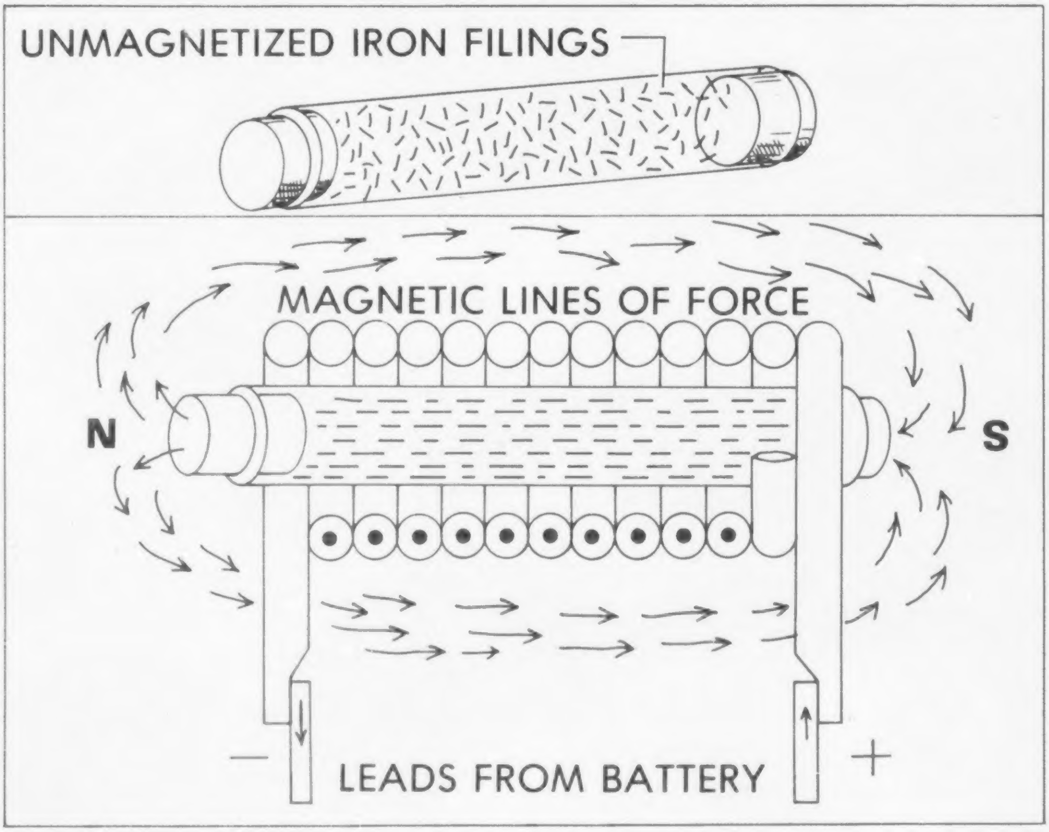
B. I = E/R 12/6 = 2 ampere
I = E/R 12/3 = 4 ampere

C. I = 6 amps
R = E/I 12/6 = 2 ohms

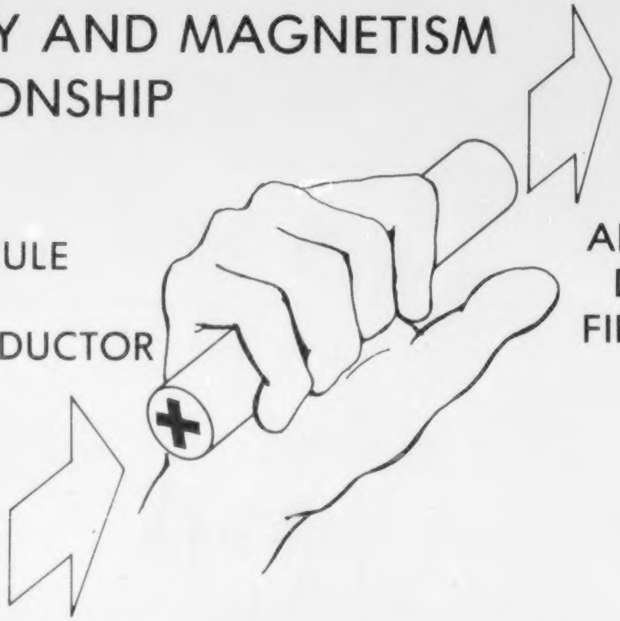




MAGNETISM AND FIELD OF FORCE


UNMAGNETIZED IRON FILINGS
MAGNETIC LINES OF FORCE
N
S
−
+
LEADS FROM BATTERY

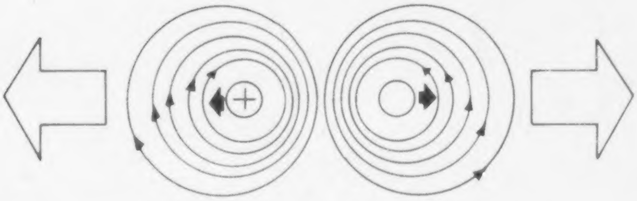
ELECTRICITY AND MAGNETISM RELATIONSHIP



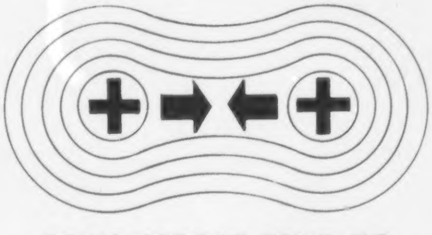
RIGHT HAND RULE
FOR
STRAIGHT CONDUCTOR

ARROWS SHOW
DIRECTION OF
FIELD OF FORCE

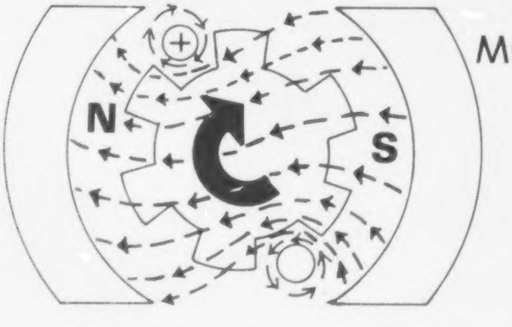
STRONG FIELD BETWEEN CONDUCTORS



CONDUCTORS TEND TO
MOVE APART

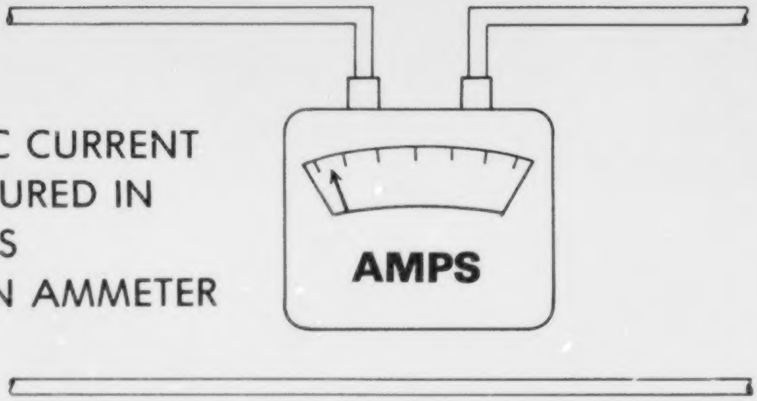


CONDUCTORS TEND TO
MOVE TOGETHER

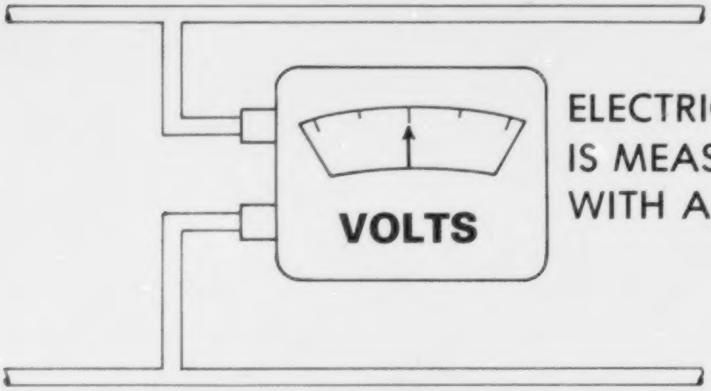


MOTOR PRINCIPLE

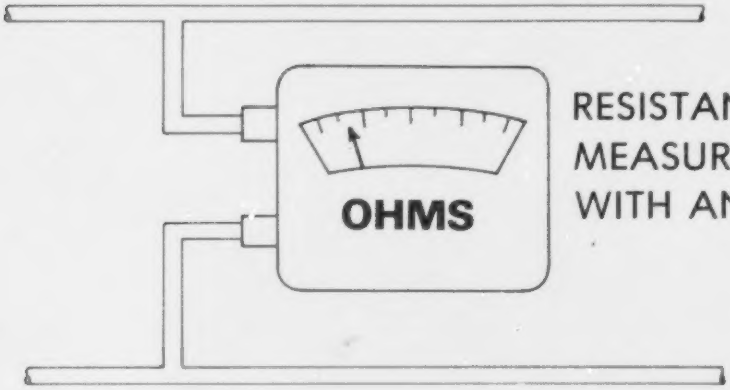
MEASURING INSTRUMENTS



ELECTRIC CURRENT
IS MEASURED IN
AMPERES
WITH AN AMMETER



ELECTRIC "PRESSURE"
IS MEASURED IN VOLTS
WITH A VOLTMETER



RESISTANCE IS
MEASURED IN OHMS
WITH AN OHMMETER

BASIC ELECTRICITY
UNIT I

ASSIGNMENT SHEET #1--SOLVE PROBLEMS USING OHM'S LAW

Read the problems and use the triangle expression of ohm's law to solve for the unknown value in each problem.

Example: Cover the unknown in the triangle and solve

(NOTE: E = Voltage; I = Amperes; R = Resistance.)

Show your work on each problem. Turn in to instructor after completion.

1. A current of 4 amperes is needed to operate a certain light bulb having a resistance of 3 ohms. What voltage is required?

2. Through how many ohms of resistance does 12 volts force a current of 12 amperes?

3. An electric horn requires 12 volts. The resistance is 20 ohms. What current does the horn take?

(NOTE: The electrical energy consumed in any resistance appears as heat. There is a definite relation between the power consumed and the heat produced. This is in accordance with the principle that energy cannot be destroyed.)

ASSIGNMENT SHEET #1

4. A light bulb having a resistance of 6 ohms uses 2 amperes of current while in operation. What is the voltage applied to the circuit?

5. A horn connected to a 12 volt battery uses 2 amperes of current for its operation. What is the resistance of the horn?

BASIC ELECTRICITY
UNIT I

ANSWERS TO ASSIGNMENT SHEET

1. Covering up the E shows the formula for this problem to be I x R. Therefore, E = IR = 4 x 3 = 12 volts.

2. Covering up the R shows that R = E/I which equals 12/12 = 1 ohm.

3. Covering up the I shows that I = E/R. Therefore, 12/20 = .6 amperes.

4. E = I x R. Therefore, 6 x 2 = 12 volts.

5. R = E/I. Therefore, 12/2 = 6 ohms.

BASIC ELECTRICITY
UNIT I

NAME______________________________

TEST

1. Match the terms on the right to the correct definitions. (Definitions are continued on the following page.)

______a. Instrument for measuring the flow of electrical current in amperes

______b. Unit of measure for electrical current

______c. Device which stores an electrical charge

______d. Continuous, unbroken path along a conductor through which electrical current can flow from a source, through various units and back to the source

______e. Substance or body through which an electrical current readily flows

______f. Flow of electrons through a conductor, measured in amperes

______g. Material which does not readily permit current flow

______h. Body which has the property of attracting iron or other magnets

______i. Power to attract other similar materials

______j. Standard unit for measuring resistance to flow of an electrical current

______k. Opposition to current flow in a conductor

______l. Inducing voltage in a conductor that moves across a magnetic field

______m. An element with an atomic configuration which makes it neither a good conductor nor insulator

1. Voltage (emf)
2. Magnetic induction
3. Ohm
4. Magnet
5. Conductor
6. Capacitor (condenser)
7. Ammeter
8. Ampere
9. Circuit
10. Current
11. Insulator
12. Magnetism
13. Resistance
14. Semiconductor

_____n. Electromotive force which causes current to flow in an electrical circuit

2. Select the sources of electricity related to small engine repair by placing an "X" in the appropriate blanks.

_____a. Pressure

_____b. Magnetic

_____c. Chemical

3. Select the parts of a basic circuit by placing an "X" in the appropriate blanks.

_____a. Conductor

_____b. Insulator

_____c. Magnet

_____d. Voltage source

_____e. Resistor

4. Distinguish between good conductors and insulators by placing a "C" in front of the items that are good conductors and an "I" in front of the items that are insulators.

_____a. Mercury

_____b. Brass

_____c. Rubber

_____d. Glass

_____e. Wood

_____f. Nickel

_____g. Plastic

_____h. Nichrome

_____i. Silver

_____j. Gold

_____k. Ceramic

_____l. Aluminum

5. Discuss direct and alternating current.

   a. Direct

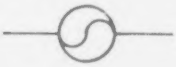
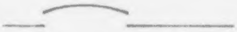
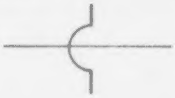
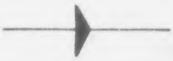
   b. Alternating

6. Explain why copper is widely used as a conductor.

7. Match the basic circuit terms on the right to their units of measure.

_____a. Ohms	1. Current
_____b. Volts	2. Resistance
_____c. Amperes	3. Voltage

8. Match the basic electrical schematic symbols on the right to the correct names.

_____a. Solenoid	1. 
_____b. Battery	2. 
_____c. Terminal	3. 
_____d. Circuit breaker	4. 
_____e. Resistance or load	

_____f. Coil

_____g. Ohms of resistance

_____h. Ground

_____i. Connection

_____j. Switch (open)

_____k. Crossover

_____l. Fuse

_____m. Diode (one-way)

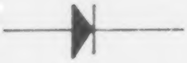
_____n. Zener diode

_____o. Capacitor

_____p. Direction of current

_____q. Silicon controlled rectifier

_____r. Rheostat

5.


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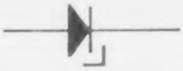

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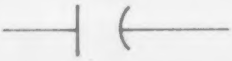

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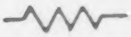

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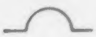

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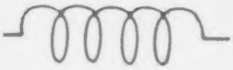

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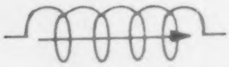

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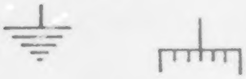

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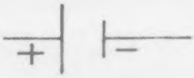

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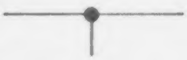

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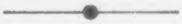

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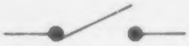
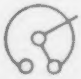
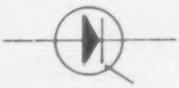


17.


18.


9. Match the letter designations used in ohm's law on the right to the correct terms.

_____a. Electromotive force in volts

_____b. Intensity in amps

_____c. Resistance in ohms

1. I
2. R
3. E

10. Draw ohm's law formula in triangle expression.

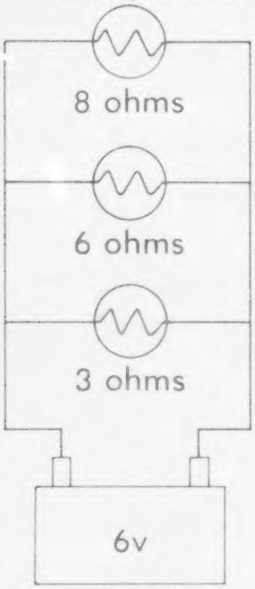
11. State ohm's law in letter formula for calculating voltage, current, and resistance.

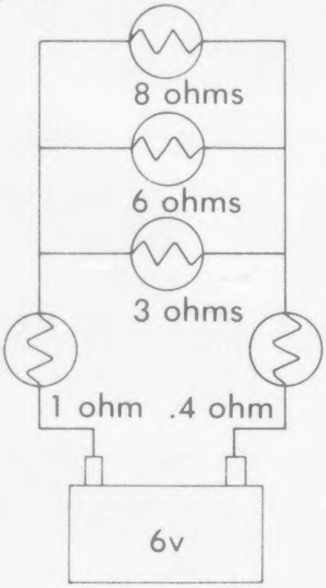
A. E=

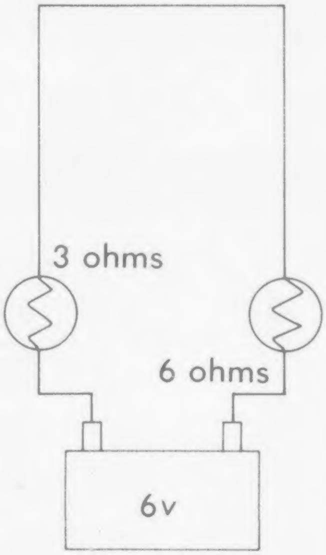
B. I=

C. R=

12. Identify the following types of electrical circuits.


8 ohms
6 ohms
3 ohms
6v


8 ohms
6 ohms
3 ohms
1 ohm
.4 ohm
6v


3 ohms
6 ohms
6v

a. ____________________ b. ____________________ c. ____________________

13. List three rules for series circuits.

a.

b.

c.

14. List three rules for parallel circuits.

a.

b.

c.

15. Select the factors effecting resistance in a conductor by placing an "X" in the appropriate blanks.

_____ a. Length

_____ b. Altitude

_____ c. Viscosity

_____ d. Diameter

_____ e. Composition

_____ f. Temperature

16. Select the characteristics of magnetism by placing an "X" in the appropriate blanks.

______a. Every magnet has a north and west pole

______b. Magnetic materials are acted upon when located in a field of resistance

______c. Every magnet has a field of force surrounding it

______d. Unlike poles attract and like poles repel

17. Explain two ways an iron bar may be magnetized.

a.

b.

18. Discuss the relationship between electricity and magnetism.

19. Select factors that determine the magnitude of induced voltage by placing an "X" in the appropriate blanks.

______a. Number of conductors that are cutting across the lines of force

______b. Strength of the magnetic field

______c. Atmospheric pressure

______d. Speed at which lines of force are cutting across the conductor

20. Select instruments used in checking electrical circuits by placing an "X" in the appropriate blanks.

    ______a. Extension cord

    ______b. Fuse

    ______c. Ammeter

    ______d. Ohmmeter

    ______e. Voltmeter

21. Solve the following problems using ohm's law formula.

    a. A current of 1.5 amperes is needed to operate a certain light bulb having a resistance of 8 ohms. What voltage is required?

    b. A horn connected to a 12 volt battery uses 4 amperes of current for its operation. What is the resistance of the horn?

BASIC ELECTRICITY
UNIT I

ANSWERS TO TEST

1. a. 7
   b. 8
   c. 6
   d. 9
   e. 5
   f. 10
   g. 11
   h. 4
   i. 12
   j. 3
   k. 13
   l. 2
   m. 14
   n. 1

2. b, c

3. a, d, e

4. a. C
   b. C
   c. I
   d. I
   e. I
   f. C
   g. I
   h. C
   i. C
   j. C
   k. I
   l. C

5. Discussion should include:
   a. Direct current
      1) Supplied by
         a) Generator
         b) Battery
            (1) Dry cell
            (2) Wet cell
      2) Flows in one direction only
      3) Abbreviated as DC
   b. Alternating current
      1) Supplied by an alternating current generator (alternator)
      2) Flows in one direction then reverses and flows in the opposite direction
      3) Abbreviated as AC

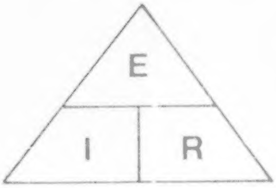
6. Copper is a good conductor because it has only one electron in outer ring and is comparitively cheaper than other metals which may have similar properties

7. a. 2
   b. 3
   c. 1

8. a. 11
   b. 13
   c. 15
   d. 2
   e. 8
   f. 10
   g. 9
   h. 12
   i. 14
   j. 16
   k. 3
   l. 1
   m. 5
   n. 6
   o. 7
   p. 4
   q. 17
   r. 18

9. a. 3
   b. 1
   c. 2

10.



11. a. E = I×R or Volts = Amps × Ohms
    b. I = E/R or Amps = Volts ÷ Ohms
    c. R = E/I or Ohms = Volts ÷ Amps

12. a. Parallel
    b. Series-parallel
    c. Series

13. a. Current through each resistor is the same
    b. Voltage drops across each resistor will be different if the resistance values are different
    c. Sum of the voltage drops equals the source voltage

14. a. Voltage across each resistor is the same

    b. Current through each resistor will be different if the resistance values are different

    c. Sum of the separate currents equals the total circuit current

15. a, d, e, f

16. c, d

17. a. Stroke an iron bar with another bar which has been magnetized

    b. Place an iron bar in a strong magnetic field

18. Discussion should include:

    a. Current passed through a wire (conductor) creates a magnetic field around the wire

    b. Magnetic lines have direction and change direction when the current flow changes from one direction to another

    c. Conductor moving across a magnetic field will have a voltage induced in it

    d. Voltage polarity and the current flow direction are determined by the direction of wire movement and direction of the lines of force

    e. Ways to induce voltage by magnetic induction

        1. Generated voltage by relative motion

        2. Self-induction voltage created by a change of current in the conductor

        3. Mutual-induction which occurs when changing current in one coil induces voltage in a second coil

    f. Two conductors on an armature, carrying current in opposite directions, create a strong and weak field on opposite sides causing conductors to move apart or armature to rotate

19. a, b, d

20. c, d, e

21. a. 12 volts

    b. 3 ohms

IGNITION SYSTEMS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the components and state the purpose of the ignition system. The student should also be able to test the coil, condenser, armature, and flywheel magnets and remove and replace contact points and condenser. The student should also be able to test and adjust a solid state ignition system and remove, service, and replace spark plugs. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. State the purpose of the ignition system.
2. Match the types of ignition systems to the correct descriptions.
3. Distinguish between the components of a primary and secondary battery ignition circuit.
4. Identify the components of a magneto ignition system.
5. Identify the components of a solid state ignition system.
6. Identify the components of a breakerless ignition system.
7. Match the components of the ignition system to the correct purposes.
8. Associate the operational steps with the ignition systems.
9. Demonstrate the ability to:
    a. Remove, service, and replace spark plugs.
    b. Remove and replace contact points and condenser.
    c. Test the coil, condenser, armature, and flywheel magnets.
    d. Test and adjust a solid state ignition system.
    e. Check ignition timing.

IGNITION SYSTEM
UNIT IX

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheet.
- F. Demonstrate and discuss the procedures outlined in the job sheets.
- G. Show examples of the different types of ignition systems.
- H. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete job sheets.
- D. Study examples of the different types of ignition systems.
- E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
  1. TM 1--Primary Circuit
  2. TM 2--Secondary Circuit

3. TM 3--Magneto Ignition System
4. TM 4--Solid State Ignition System
5. TM 5--Breakerless Ignition System
6. TM 6--Principles of a Magneto
7. TM 7--Principles of a Magneto (Continued)
8. TM 8--Principles of a Magneto (Continued)

D. Job sheets

1. Job Sheet #1--Remove, Service, and Replace Spark Plugs
2. Job Sheet #2--Remove and Replace Contact Points and Condenser
3. Job Sheet #3--Test the Coil, Condenser, Armature, and Flywheel Magnets
4. Job Sheet #4--Test and Adjust a Solid State Ignition System
5. Job Sheet #5--Check Ignition Timing

E. Test

F. Answers to test

II. Reference--Roth, Alfred C. *Small Gas Engines.* South Holland, Illinois: Goodheart-Willcox Co., 1975.

IGNITION SYSTEM
UNIT IX

INFORMATION SHEET

I. Purpose of the ignition system--Produces high voltage current to ignite the fuel-air mixture in the engine cylinder

II. Types of ignition systems

  A. Battery ignition system--Uses battery to supply source of current for the primary ignition circuit

  B. Magneto ignition system--Produces current by magnetic induction for the primary ignition circuit without any outside source of electricity

  C. Solid state ignition system--Uses semiconductors in place of one or more standard ignition components

  D. Breakerless ignition system--Uses electronic parts in place of mechanically operated ignition points

III. Battery ignition systems circuit components (Transparencies 1 and 2)

  A. Primary circuit (low voltage)

    1. Battery

    2. Ignition switch

    3. Resistance unit (resistor)

    4. Primary winding

    5. Contact points

    6. Condenser

    7. Low voltage wire

  B. Secondary circuit (high voltage)

    1. Secondary winding

    2. Distributor cap

    3. Rotor

INFORMATION SHEET

4. Spark plug
5. High voltage wire

IV. Components of a magneto ignition system (Transparency 3)

A. Primary system (low voltage)

1. Flywheel with magnets
2. Armature
3. Switch stop
4. Coil
5. Contact points
6. Condenser

B. Secondary system (high voltage)

1. Spark plug
2. High voltage wire

V. Components of a solid state ignition system (Transparency 4)

A. Flywheel with magnets

B. Trigger coil

C. Resistor

D. Transistorized rectifier (solid state switch)

E. Diode rectifier

F. Ignition coil

G. Low voltage wire

(NOTE: The same secondary circuit components are used on the solid state ignition system that are used on the magneto ignition system.)

INFORMATION SHEET

VI. Components of a breakerless ignition system (Transparency 5)

A. Battery

B. Flywheel

C. Trigger module

D. Ignition switch

E. Alternator-stator

F. Ignition coil assembly

G. Rectifier-regulator

H. Low voltage wire

(NOTE: The same secondary circuit components are used on the breakerless ignition system that are used on the magneto ignition system.)

VII. Purpose of the ignition system components

A. Battery--Source of electrical power

B. Ignition switch--Opens and closes the primary circuit from the battery or coil to the contact points

C. Coil--Transforms low voltage into high voltage necessary to jump the spark plug gap

D. Contact points--Make and break the primary circuit to allow the coil to produce high voltage at the spark plug

E. Condenser--Stores extra current as the contact points open to prevent arcing and burning

F. Breaker cam--Opens the contact points

G. Diode rectifier--Changes alternating (AC) current to direct (DC) current

H. Capacitor--Used in solid state ignition systems and operates like the condenser

I. Trigger coil--Generates a small amount of current that is used to activate the current from the capacitor

J. Resistor--Reduces voltage in the primary circuit to protect the contact points

INFORMATION SHEET

K. Spark plug--Provides a spark gap inside the engine cylinder to ignite the fuel-air mixture

L. Low voltage wire--Carries low voltage from the battery or armature to the primary side of the ignition coil

(NOTE: This is a wire with thin insulation.)

M. High voltage wire--Carries high voltage from the secondary side of the coil to the spark plug

(NOTE: This is a heavily insulated wire.)

VIII. Operation of the ignition systems (Transparencies 1, 2, 4, 6, 7, and 8)

A. Battery

1. With the ignition switch on and the contact points closed, low voltage current flows from the battery through the primary windings of the coil and through the contact points to ground

2. The flow of low voltage current through the primary windings of the coil causes a magnetic field buildup

3. As the contact points open, current attempts to continue to flow across the point surfaces; the condenser attached to the points absorbs this flow of current

4. Stopping the flow of current causes the magnetic field of the coil to collapse across the secondary coil windings, causing a high voltage surge

5. The high voltage surge is directed from the secondary windings of the coil through the distributor cap and rotor and on to the spark plug to ground

B. Magneto

1. With the ignition switch on or the contact points closed, low voltage current is induced by magnets through the primary windings of the coil and through the contact points to ground

2. The flow of low voltage current through the primary windings of the coil causes a magnetic field buildup

3. As the contact points open, current attempts to continue to flow across the point surfaces; the condenser attached to the points absorbs this flow of current

INFORMATION SHEET

4. Stopping the flow of current causes the magnetic field of the coil to collapse across the secondary coil windings, causing a high voltage surge

5. The high voltage surge is directed from the secondary windings of the coil through the secondary wire on to the spark plug to ground

C. Solid state

1. With the ignition switch on, low voltage current from the flywheel magnet induces alternating current (AC) in charge coil

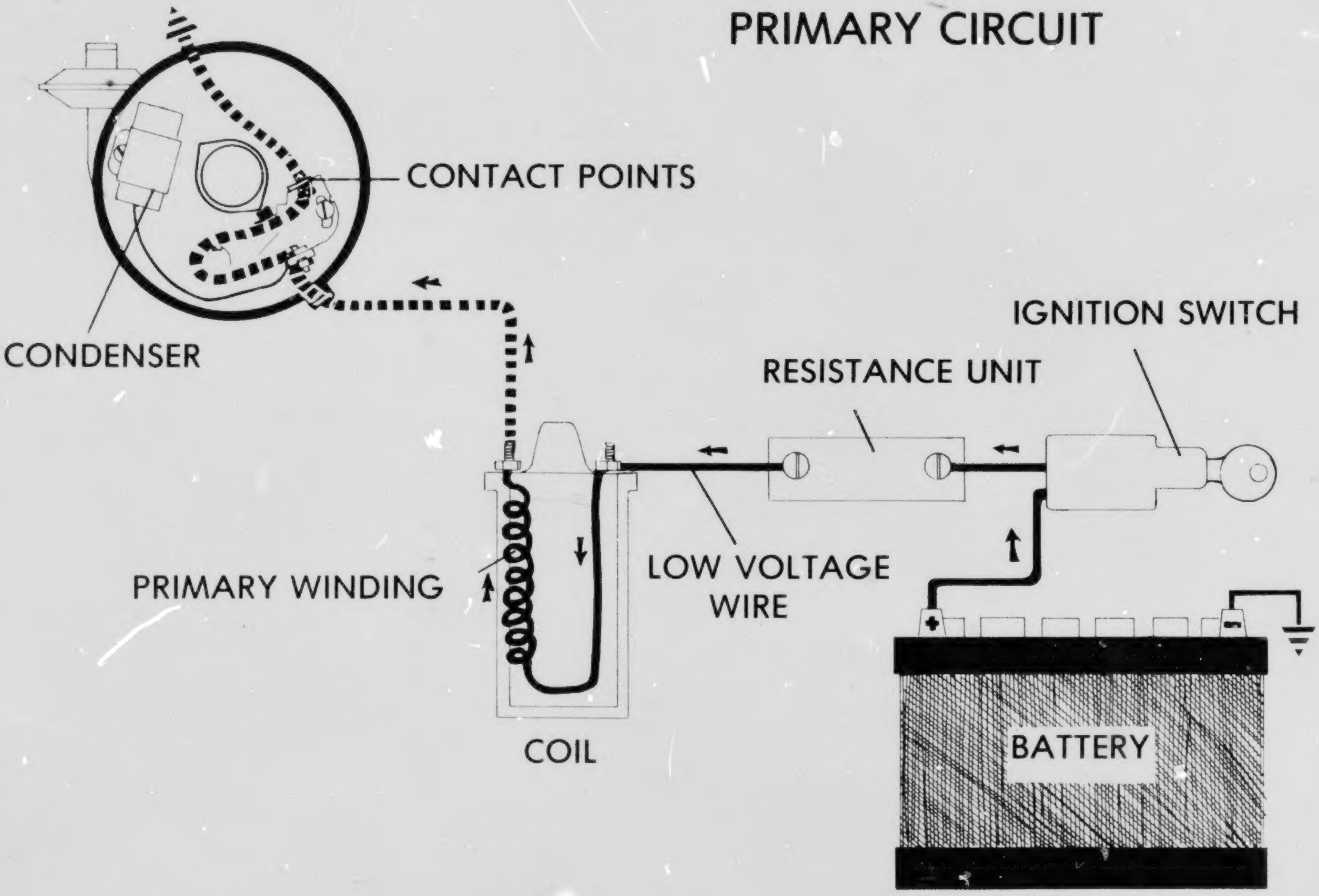
2. The AC current passes through a rectifier and changes to direct current (DC), which travels to the capacitor (condenser) where it is stored

3. The flywheel magnets pass the trigger coil and induce a small electrical charge, which turns on the silicon controlled rectifier (SCR)

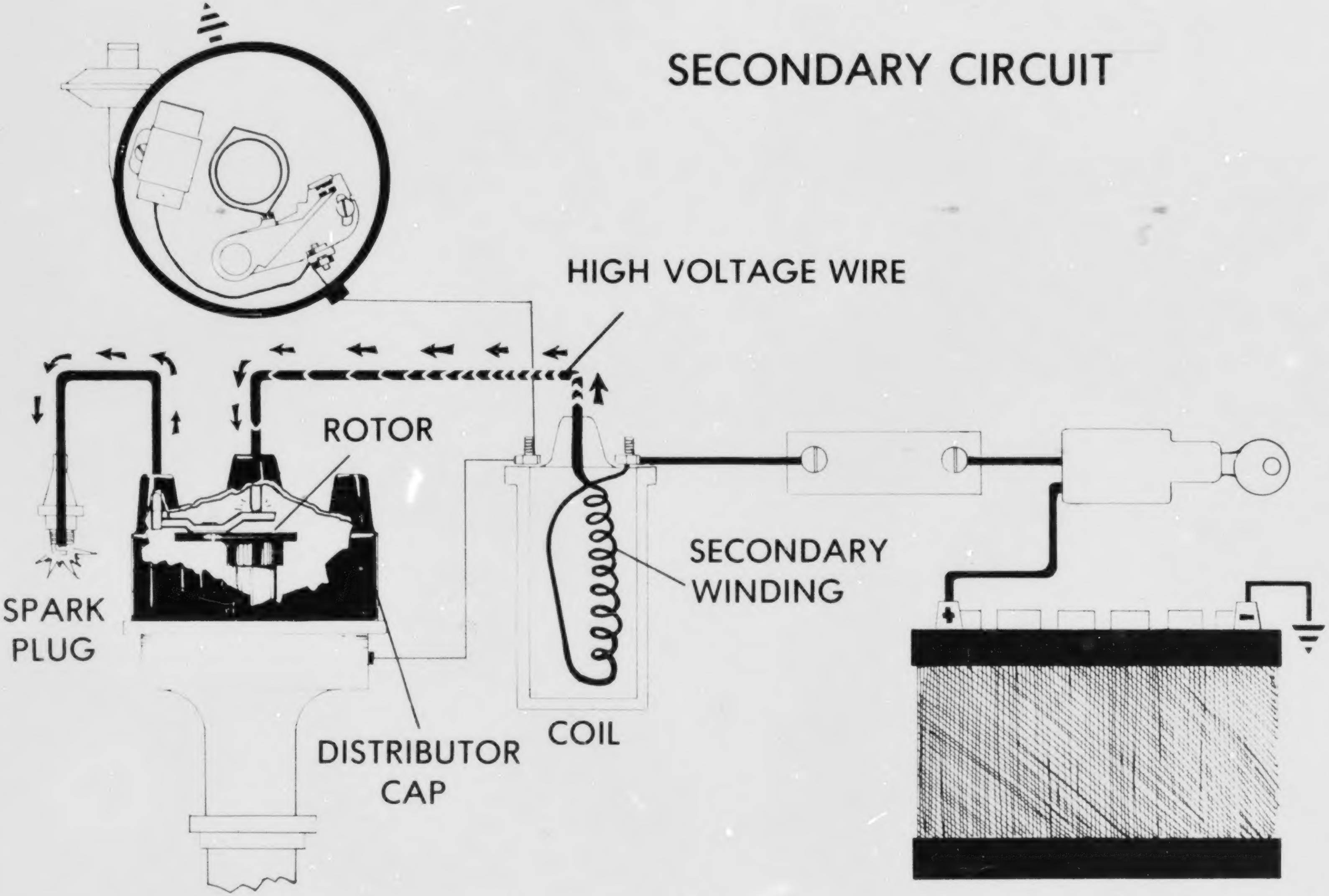
   (NOTE: This completes the circuit from the charged side of the high tension coil to the negative side of the capacitor.)

4. The instantaneous discharge of energy induces a very high density magnetic field around the primary winding of the coil, which cuts the secondary winding and thus creates sufficient energy to fire the spark plug

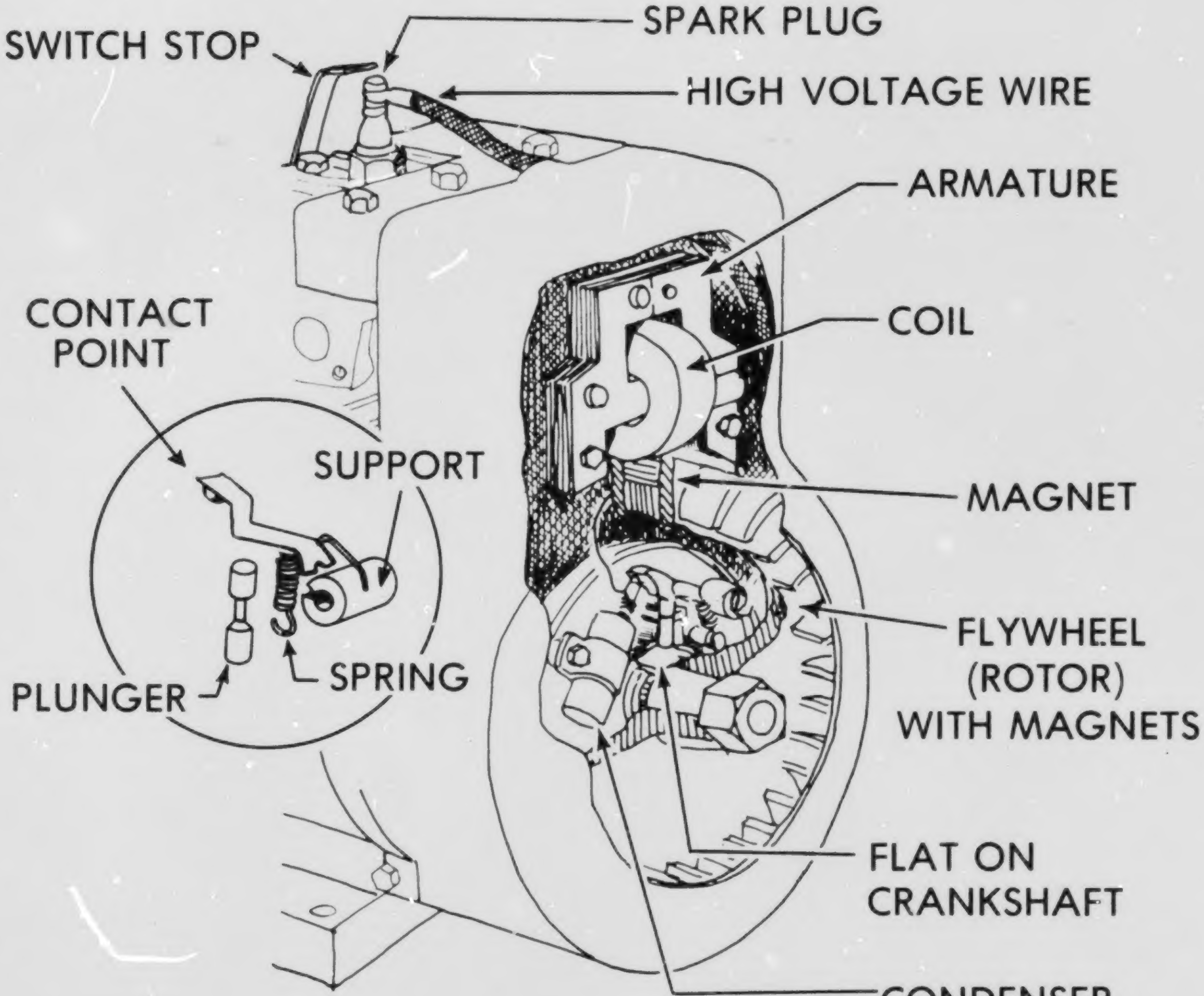
PRIMARY CIRCUIT


CONTACT POINTS
CONDENSER
IGNITION SWITCH
RESISTANCE UNIT
PRIMARY WINDING
LOW VOLTAGE WIRE
COIL
BATTERY
+
-

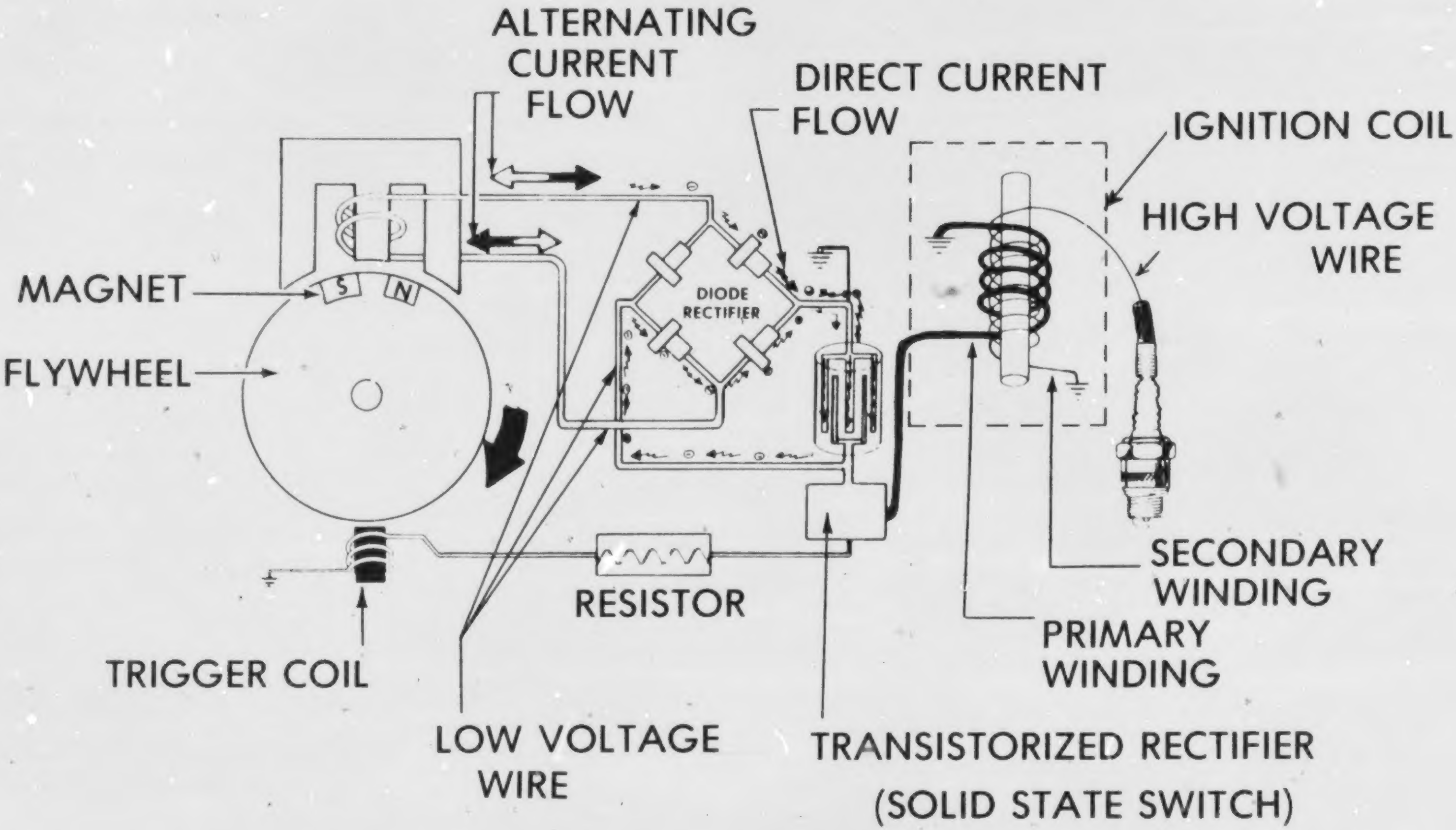
SECONDARY CIRCUIT


HIGH VOLTAGE WIRE
ROTOR
SPARK PLUG
DISTRIBUTOR CAP
COIL
SECONDARY WINDING
+
-

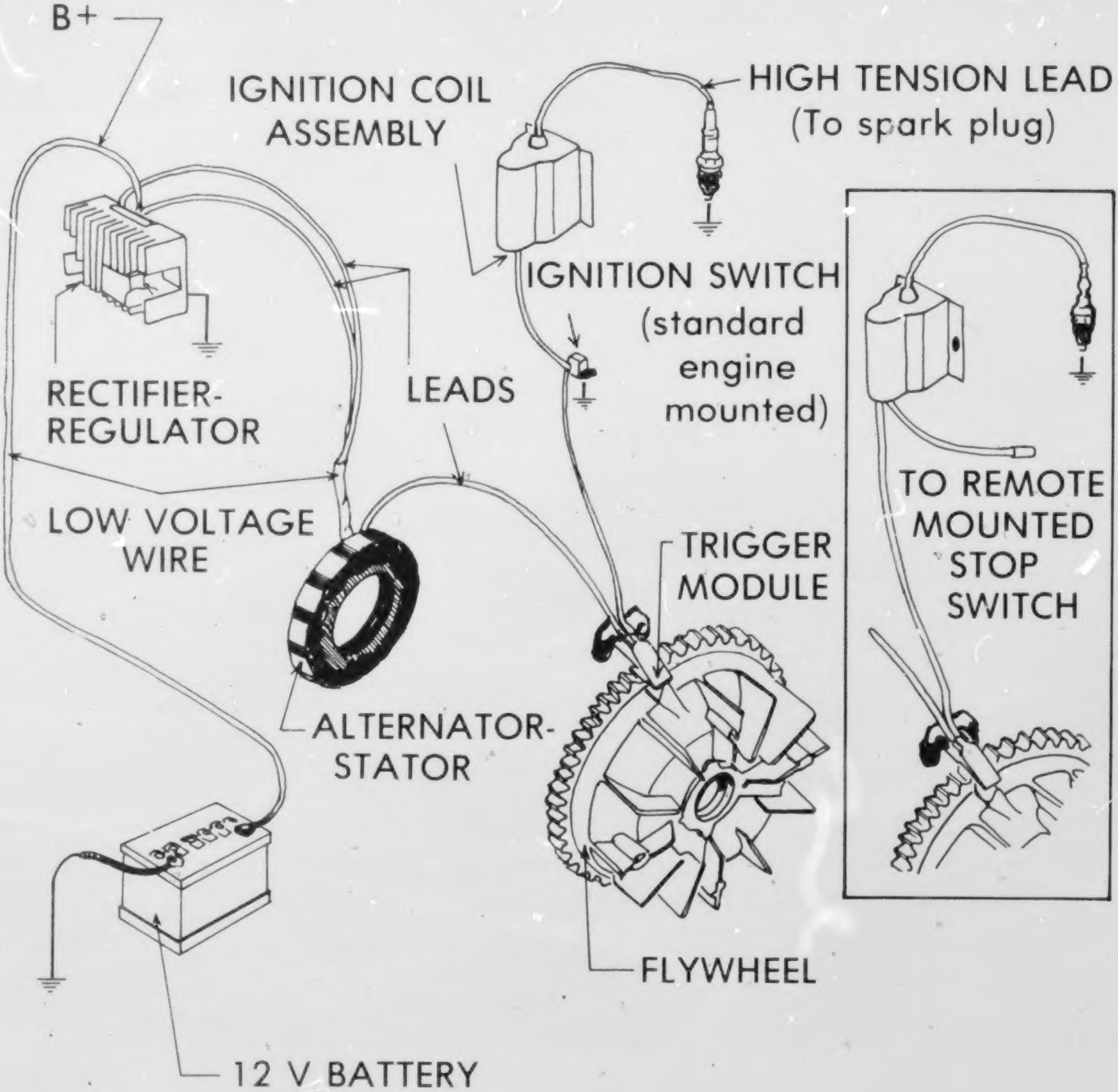
MAGNETO IGNITION SYSTEM


SWITCH STOP
SPARK PLUG
HIGH VOLTAGE WIRE
ARMATURE
CONTACT POINT
COIL
SUPPORT
MAGNET
FLYWHEEL (ROTOR) WITH MAGNETS
PLUNGER
SPRING
FLAT ON CRANKSHAFT
CONDENSER

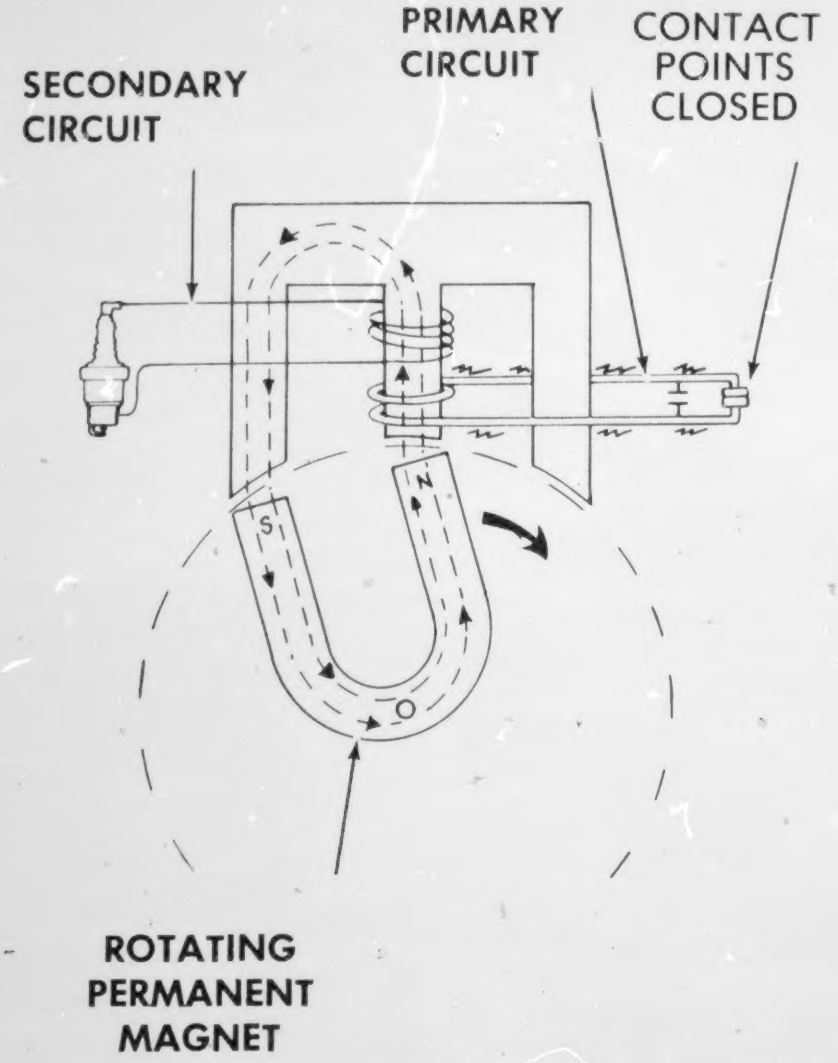
SOLID STATE IGNITION SYSTEM

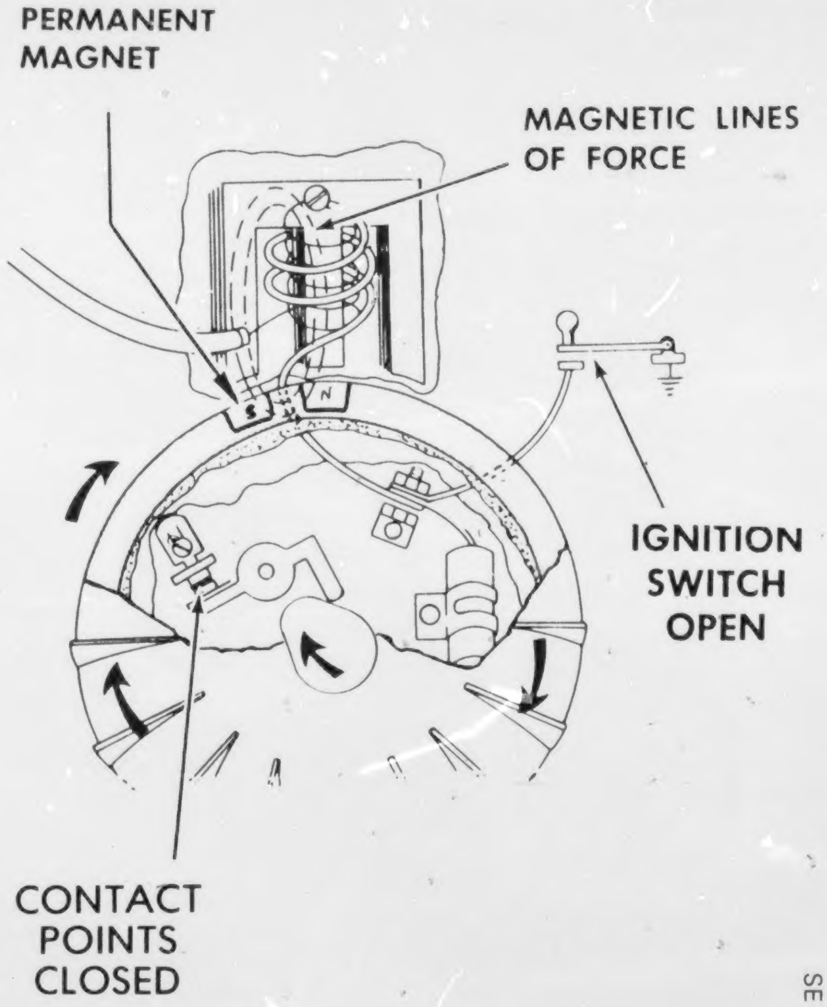

ALTERNATING CURRENT FLOW
DIRECT CURRENT FLOW
IGNITION COIL
HIGH VOLTAGE WIRE
MAGNET
S
N
FLYWHEEL
DIODE RECTIFIER
SECONDARY WINDING
PRIMARY WINDING
RESISTOR
TRIGGER COIL
LOW VOLTAGE WIRE
TRANSISTORIZED RECTIFIER (SOLID STATE SWITCH)

BREAKERLESS IGNITION SYSTEM

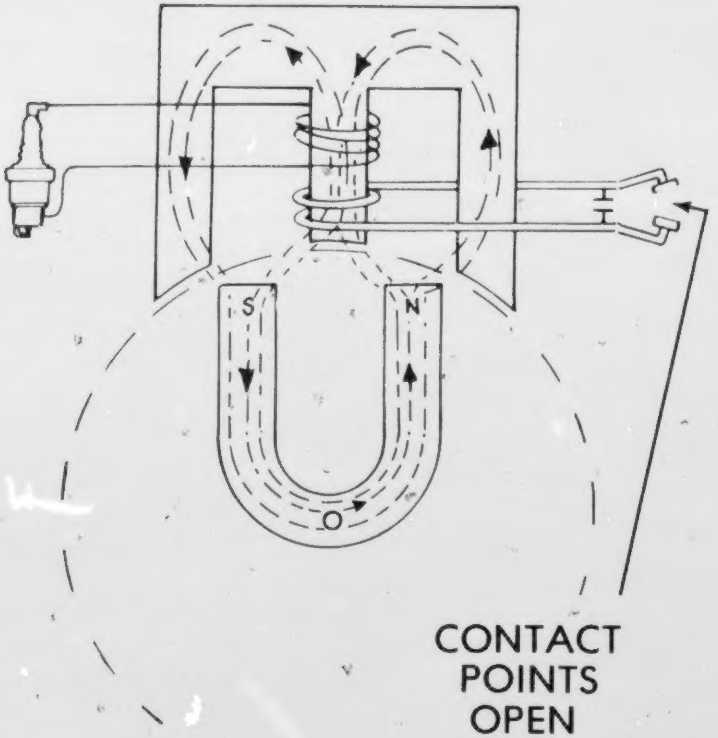

B+
IGNITION COIL ASSEMBLY
HIGH TENSION LEAD (To spark plug)
IGNITION SWITCH (standard engine mounted)
RECTIFIER-REGULATOR
LEADS
LOW VOLTAGE WIRE
TRIGGER MODULE
TO REMOTE MOUNTED STOP SWITCH
ALTERNATOR-STATOR
FLYWHEEL
12 V BATTERY

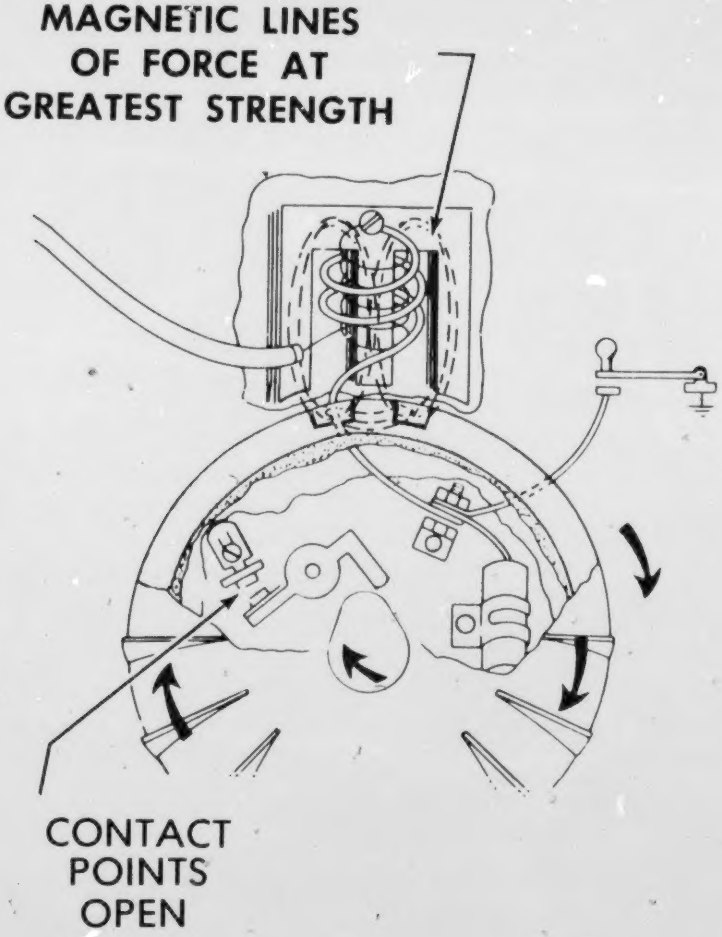
PRINCIPLES OF A MAGNETO


SECONDARY CIRCUIT
PRIMARY CIRCUIT
CONTACT POINTS CLOSED
S
N
ROTATING PERMANENT MAGNET

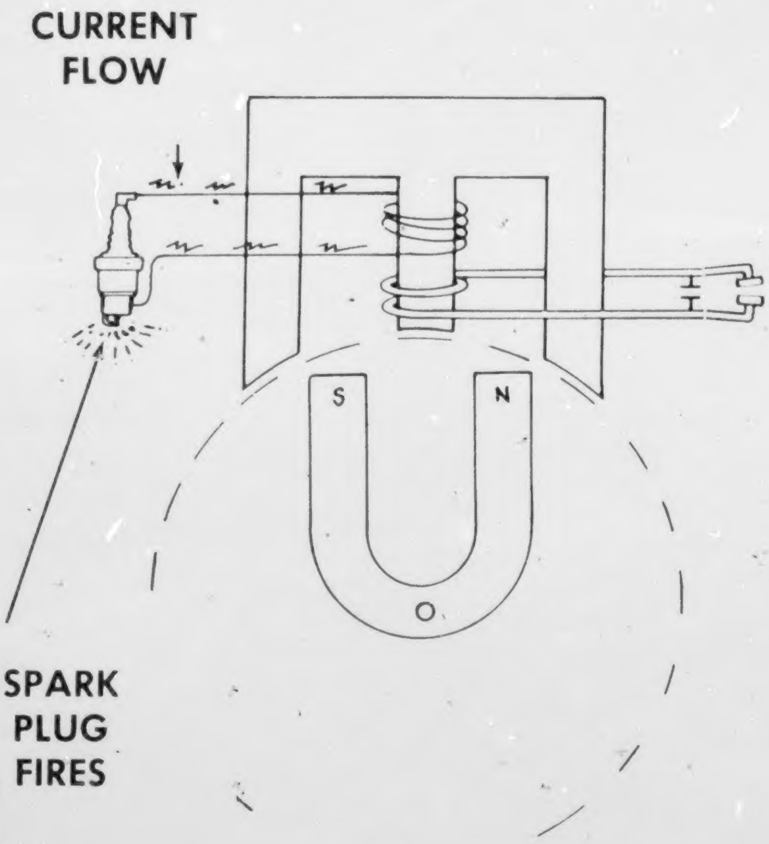

PERMANENT MAGNET
MAGNETIC LINES OF FORCE
S
N
IGNITION SWITCH OPEN
CONTACT POINTS CLOSED

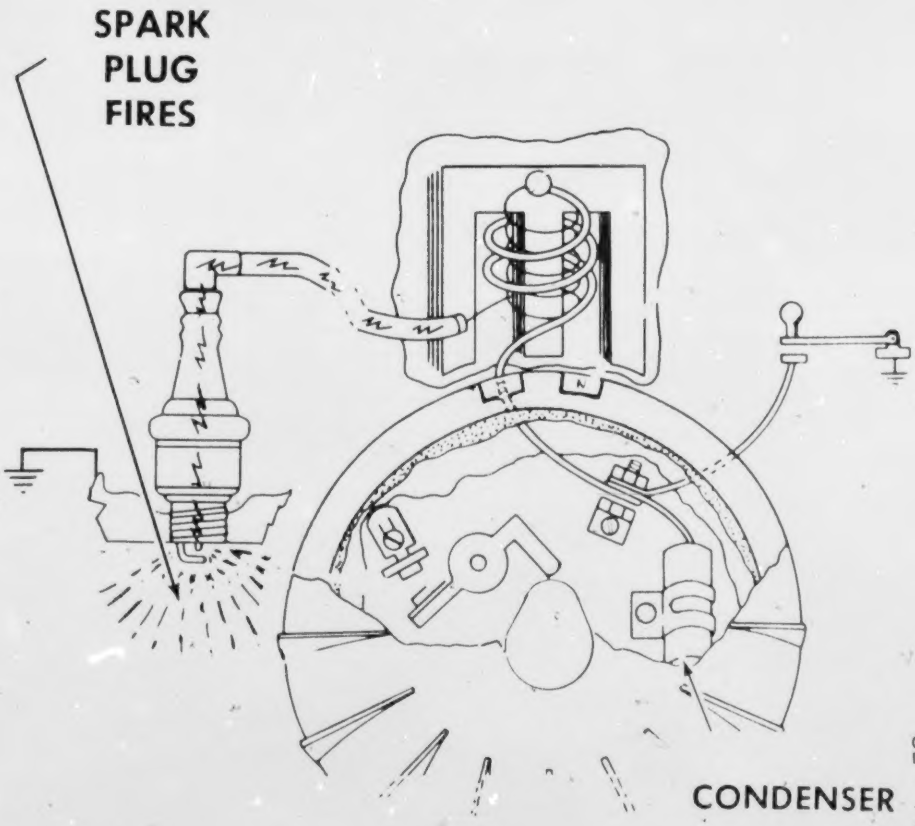
PRINCIPLES OF A MAGNETO
(Continued)


S
N
O
CONTACT POINTS OPEN


MAGNETIC LINES OF FORCE AT GREATEST STRENGTH
CONTACT POINTS OPEN

PRINCIPLES OF A MAGNETO
(Continued)


CURRENT FLOW
S
N
SPARK PLUG FIRES


SPARK PLUG FIRES
CONDENSER

IGNITION SYSTEM
UNIT IX

JOB SHEET #1 REMOVE, SERVICE, AND REPLACE SPARK PLUGS

I. Tools and materials

- A. Hand tool assortment
- B. Wire feeler gauge
- C. Ignition file
- D. Wire brush
- E. Spark tester
- F. Safety glasses

II. Procedure

- A. Clean around spark plug by blowing out dirt with compressed air
- B. Disconnect spark plug wire by grasping terminal and pulling upward (Figure 1)

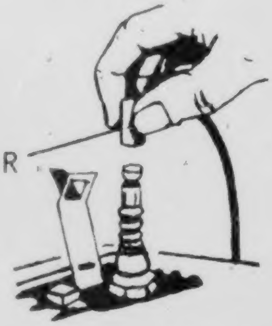


FIGURE 1

- C. Loosen the spark plug and remove (Figure 2)

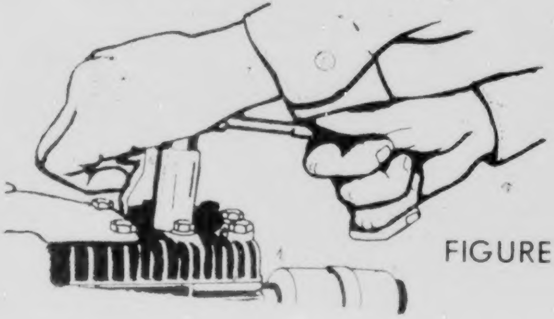


FIGURE 2

JOB SHEET #1

D. Reconnect spark plug wire

E. Ground spark plug to engine (Figure 3)

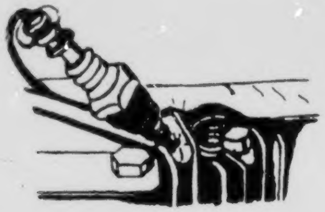


FIGURE 3

F. Crank engine one or two turns

G. Observe spark at the electrode

(NOTE: If there is no spark or the spark is weak, proceed to next step.)

H. Disconnect the spark plug wire from the spark plug

I. Hold end of the spark plug wire approximately 1/4 inch from the cylinder head or use a spark tester (Figure 4)

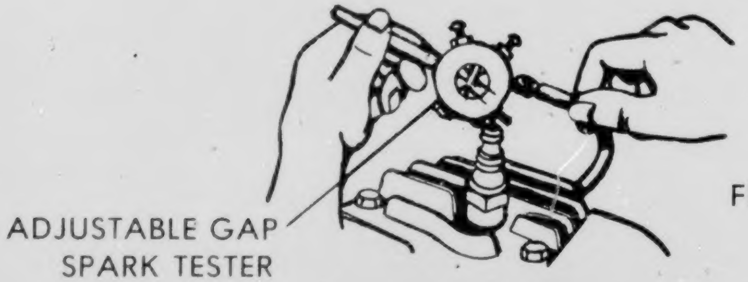


FIGURE 4

J. Crank the engine one or two turns

K. Observe the spark

(NOTE: If spark jumps gap on tester, the ignition system is okay; the trouble is in the spark plug.)

L. Service the spark plug

1. Clean threads with a wire brush

   (NOTE: Using a spark plug cleaning machine is not recommended because this will void most small engine warranties.)

JOB SHEET #1

2. Bend the ground electrode slightly to open gap (Figure 5)

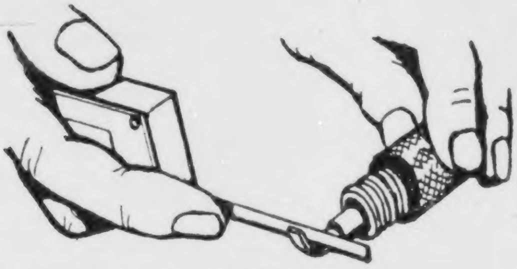


FIGURE 5

3. File the electrodes to flatten the surface and square the edges

4. Gap plugs to manufacturer's specifications

(NOTE: Use a wire gauge and bend only the ground electrode. See Figure 6.)

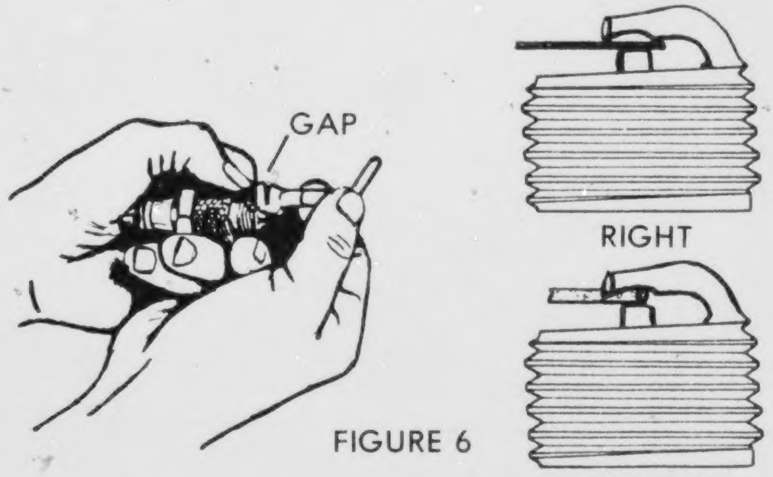


FIGURE 6

M. Install spark plug and tighten

(NOTE: Use caution when starting the spark plug to avoid cross threading.)

N. Torque the spark plug to manufacturer's recommendations

O. Replace the spark plug wire

P. Have instructor evaluate work

Q. Clean work area and return tools to proper location

IGNITION SYSTEM
UNIT IX

JOB SHEET #2--REMOVE AND REPLACE CONTACT POINTS AND CONDENSER

I. Tools and materials

- A. Flywheel removal tools
- B. Ignition tools and wrenches
- C. Feeler gauge set .010 - .025
- D. Screwdrivers
- E. Cam lubricant
- F. Shop towels
- G. Electrical cleaner
- H. Hand tool assortment
- I. Safety glasses

II. Procedure

A. Find location of points and condenser

(NOTE: On most engines this will be under the flywheel. Some will be located externally on the side of the block.)

B. Remove engine shroud and any parts necessary to get at the flywheel

C. Remove flywheel

(NOTE: Check for left-hand threads on crankshaft; use special flywheel removal tools as required. See Figures 1 and 2.)

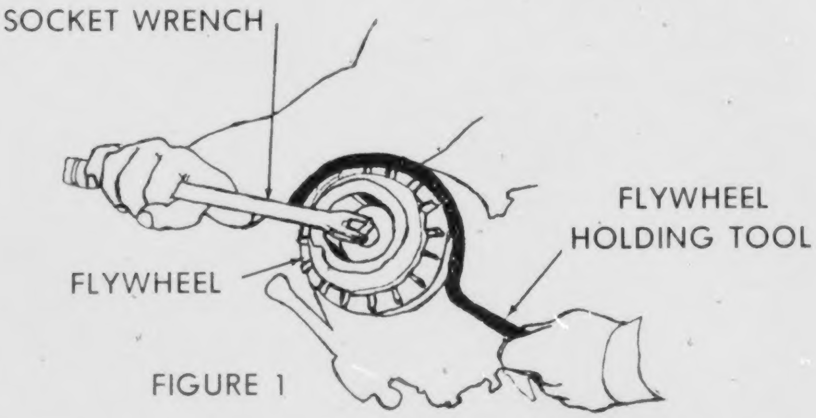


FIGURE 1

JOB SHEET #2

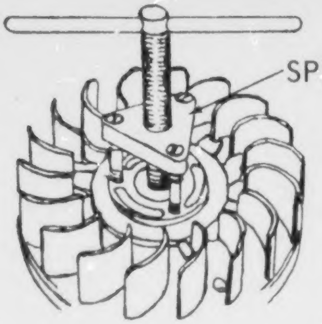


FIGURE 2

D. Remove points and condenser cover

(NOTE: Some covers have a sealer at the point where the wires enter. Save this for reuse.)

E. Determine location and condition of all wires, screws, and breaker cam

F. Disconnect contact point primary lead wire and condenser wire

G. Remove screw(s) holding contact points in place

H. Remove contact point set

I. Remove screw holding condenser in place

JOB SHEET #2

J. Remove condenser

(NOTE: Some engines use a pushrod to open and close the points. Remove and replace if not within manufacturer's specifications. See Figure 4.)

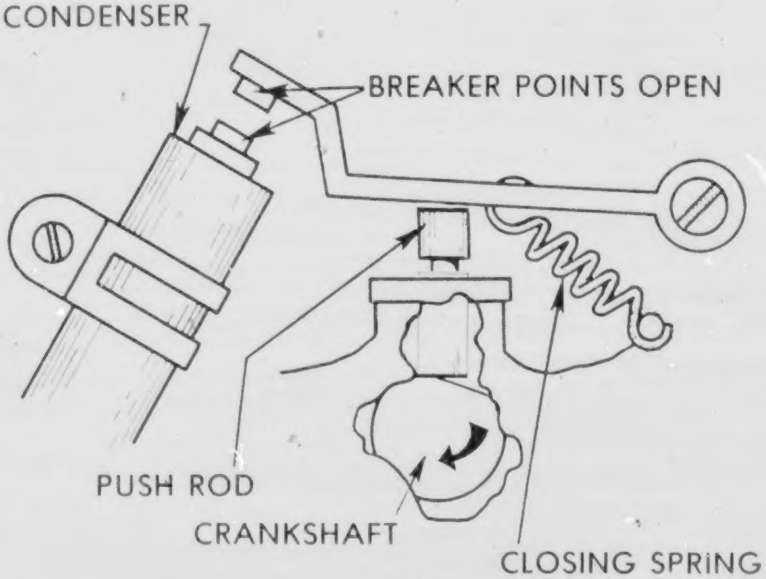


FIGURE 4

K. Clean the point and condenser area with an approved electrical cleaner

(NOTE: Check the oil seal located in the point area to be sure it is not leaking oil onto the points.)

L. Lubricate the breaker cam with a light coating of cam lubricant

M. Replace the points and condenser leaving the mounting screws loose until points are adjusted

N. Replace the primary lead and condenser wires

(NOTE: Position the wires in such a manner to avoid binding or grounding. Some models may require a spring compressor that comes with the point set.)

O. Tighten primary lead and condenser wires securely

P. Check point alignment and adjust as needed (Figure 5)

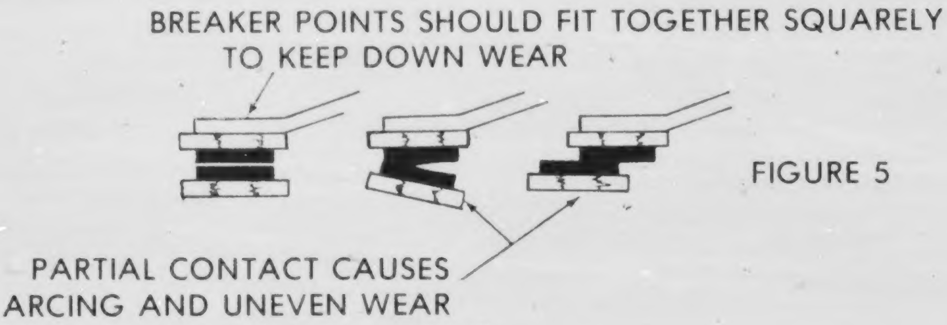

BREAKER POINTS SHOULD FIT TOGETHER SQUARELY TO KEEP DOWN WEAR
PARTIAL CONTACT CAUSES ARCING AND UNEVEN WEAR

FIGURE 5

Q. Adjust the contact point opening

(NOTE: Turn the crank to position the rubbing block of the contact points on the peak of the cam lobe. See Figure 6.)

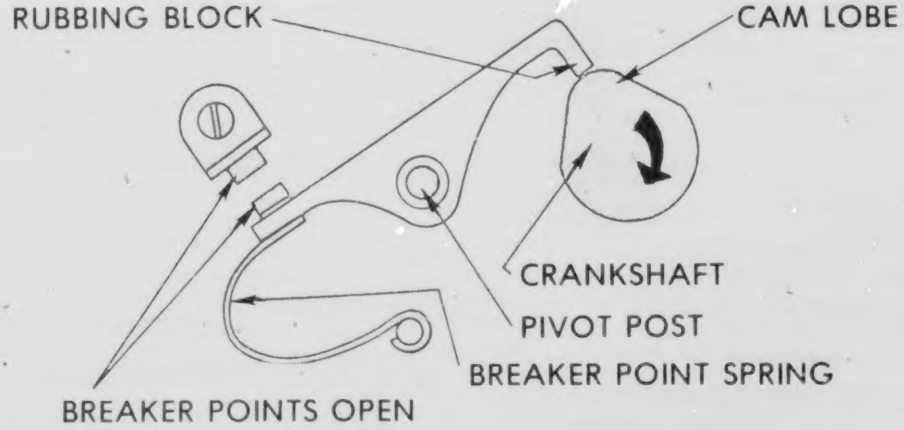

RUBBING BLOCK
CAM LOBE
CRANKSHAFT
PIVOT POST
BREAKER POINT SPRING
BREAKER POINTS OPEN

FIGURE 6

JOB SHEET #2

R. Adjust contact points to manufacturer's recommendations (Figure 7)

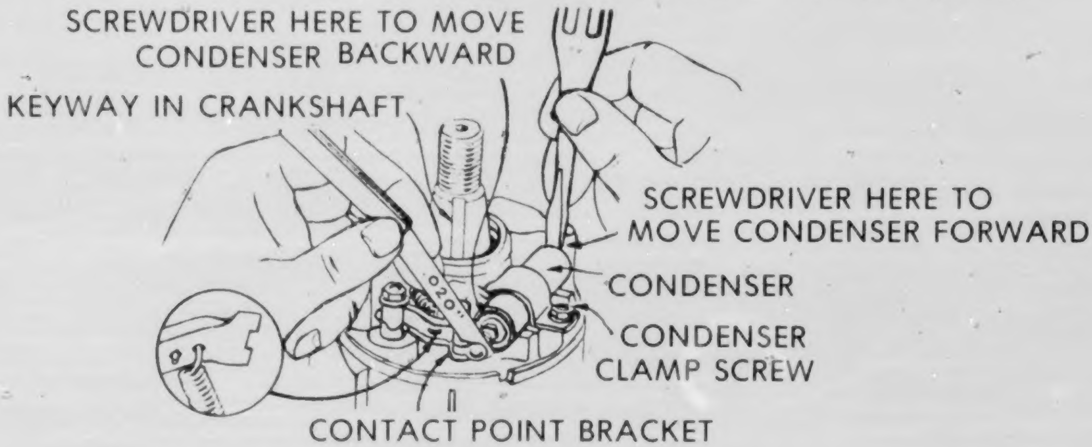
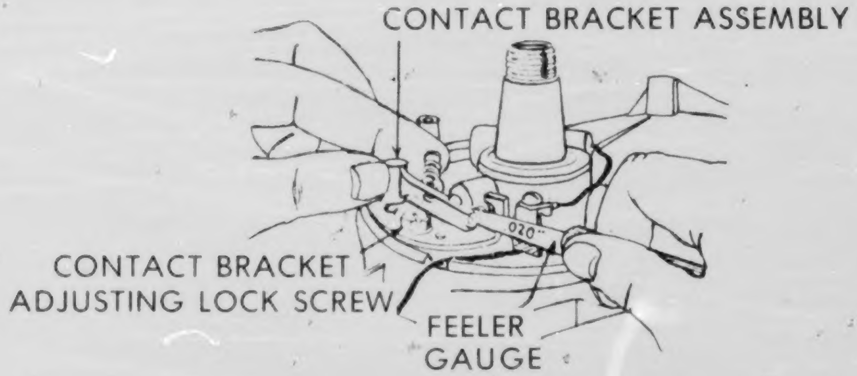

SCREWDRIVER HERE TO MOVE CONDENSER BACKWARD
KEYWAY IN CRANKSHAFT
SCREWDRIVER HERE TO MOVE CONDENSER FORWARD
CONDENSER
CONDENSER CLAMP SCREW
CONTACT POINT BRACKET
.020"

FIGURE 7


CONTACT BRACKET ASSEMBLY
CONTACT BRACKET ADJUSTING LOCK SCREW
FEELER GAUGE
.020"

S. Tighten all contact and point screws securely; recheck contact point opening

T. Install dust cover; be sure gasket or sealing compound is in place

JOB SHEET #2

U. Replace flywheel using correct flywheel key (Figure 8)

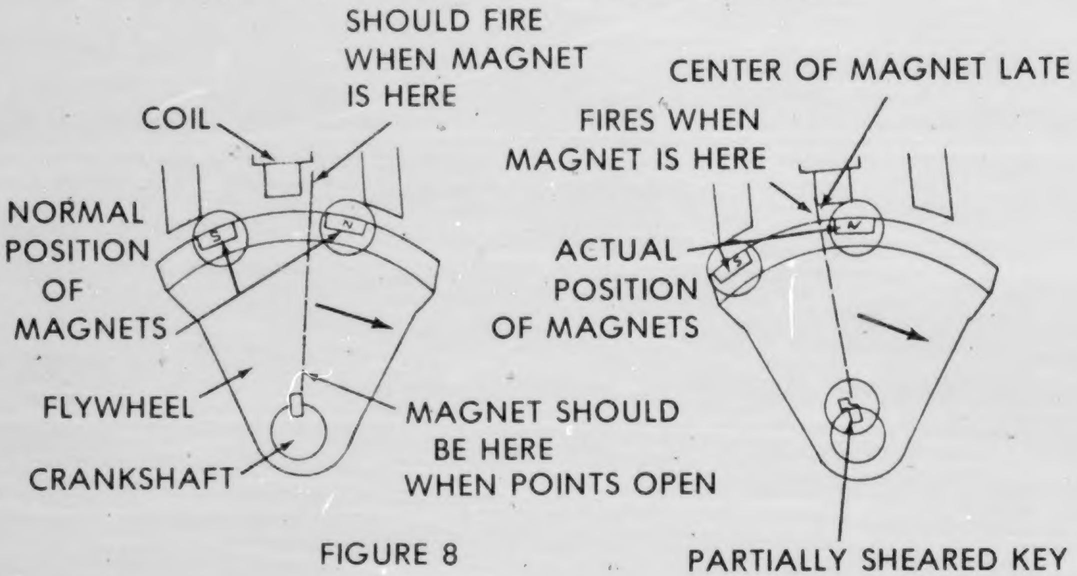

SHOULD FIRE WHEN MAGNET IS HERE
COIL
NORMAL POSITION OF MAGNETS
S
N
FLYWHEEL
CRANKSHAFT
MAGNET SHOULD BE HERE WHEN POINTS OPEN
CENTER OF MAGNET LATE
FIRES WHEN MAGNET IS HERE
ACTUAL POSITION OF MAGNETS
S
N
PARTIALLY SHEARED KEY

FIGURE 8

V. Have instructor evaluate work

W. Clean up work area and return tools to proper location

IGNITION SYSTEM
UNIT IX

JOB SHEET #3-TEST THE COIL, CONDENSER, ARMATURE, AND FLYWHEEL MAGNETS

I. Tools and materials

A. Hand tool assortment

B. Ignition analyzer

C. Small thin cardboard (post card)

D. Electrical system cleaner

E. Shop towels

F. Safety glasses

II. Procedure

A. Remove all parts necessary to get at coil and armature

B. Determine correct location of coil and armature

(NOTE: If there are not locating marks (arrows, dots, etc.) to accurately locate coil or armature, mark it and the engine block before removing. Use a small center punch or chisel to mark with.)

C. Remove coil and armature

(NOTE: It is possible to test the coil and armature without removing it from the engine.)

JOB SHEET #3

D. Test coil and armature.

1. Test primary resistance

   a. Following instructions for tester, connect leads (Figure 1)

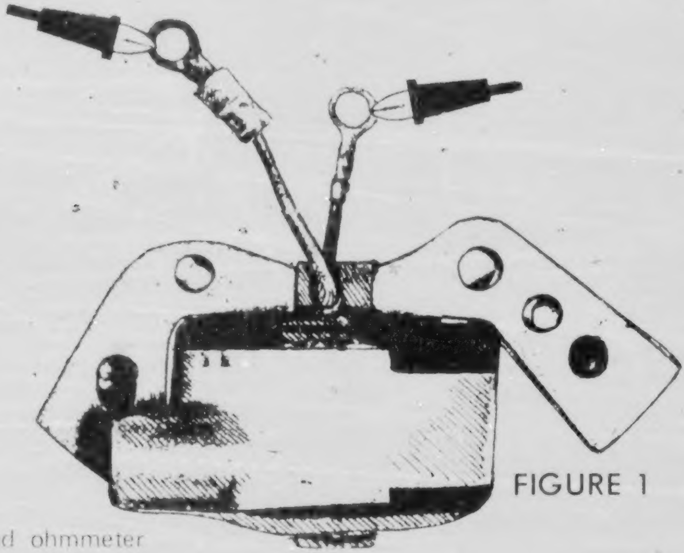


FIGURE 1

   b. Read ohmmeter

   (NOTE: Reading must be of value shown on engine specification sheet.)

2. Test continuity

   a. Following instructions for tester, connect leads (Figure 2)

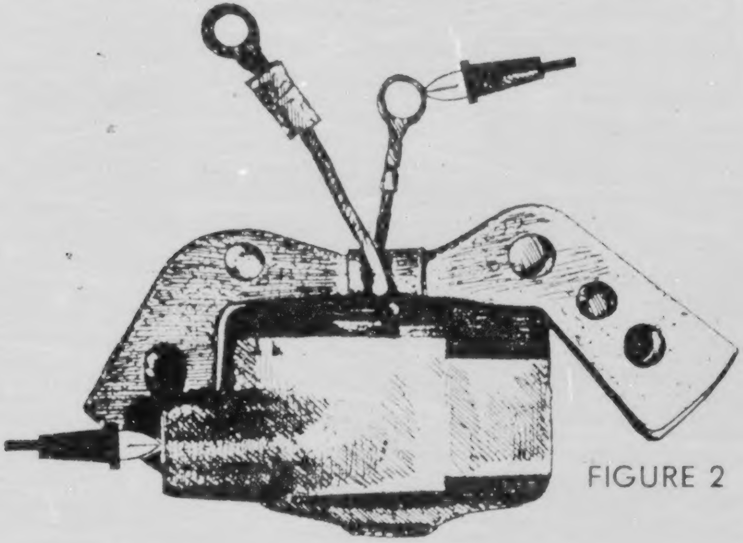


FIGURE 2

JOB SHEET #3

b. Read ohmmeter

(NOTE: Shorted windings are indicated by a lower than specified value. A broken winding is indicated by readings higher than the specified value.)

3. Test coil ground

a. Following instructions for tester, connect leads (Figure 3)

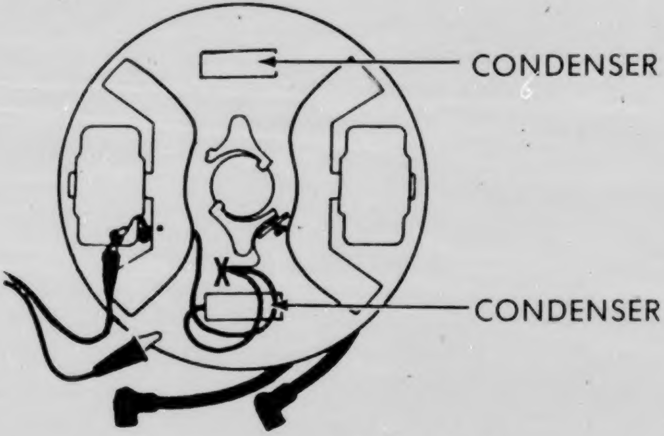


FIGURE 3

b. Read ohmmeter

(NOTE: Coils not permanently grounded should not indicate any pointer movement when tested. Coils permanently grounded must show a full deflection of the meter needle to the right of the scale.)

4. Test power

a. Following instructions for tester, properly connect test leads

JOB SHEET #3

b. Advance current control knob until specified operating amperage is reached on scale

(NOTE: If there is no spark or it is faint or intermittent, the coil is bad.)

5. If the coil fails any of the tests, replace it with a new coil

E. Replace all defective parts

F. Test flywheel magnets

(NOTE: Hold a screwdriver one inch from the magnet. It should be strongly attracted to the magnet. Most magnets are damaged by dropping the flywheel, or storing flywheels nested in one another.)

G. Replace bad magnets

(NOTE: Usually, the whole flywheel must be replaced.)

H. Install coil and armature in correct position

(NOTE: Do not overtighten mounting screws because these threads are easy to strip.)

I. Follow manufacturer's specifications for clearances, adjustments, and torque setting (Figure 5)

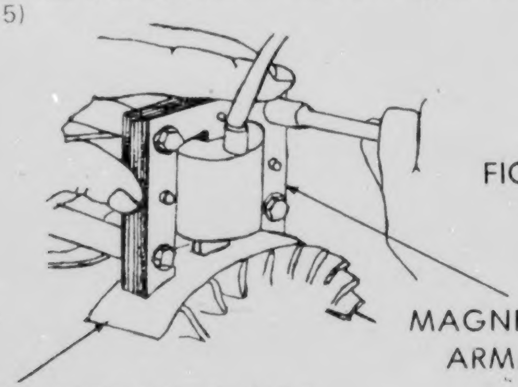


FIGURE 5

J. Install all other parts on engine

K. Start engine and adjust to recommended specifications

L. Have instructor evaluate work

M. Clean up work area and return tools to proper location

IGNITION SYSTEM
UNIT IX

JOB SHEET #4 TEST AND ADJUST A SOLID STATE IGNITION SYSTEM

I. Tools and materials

   A. Hand tool assortment

   B. Set flat feeler gauge .005 – .010

   C. Ohmmeter

   D. Safety glasses

II. Procedure

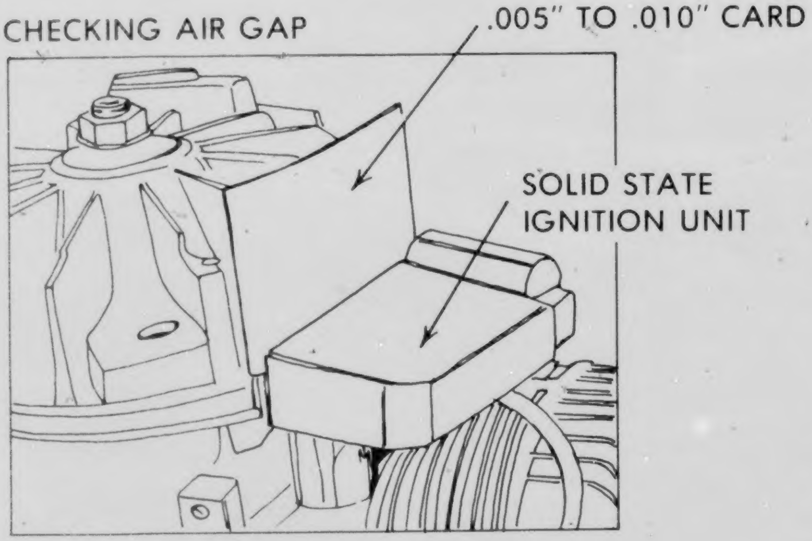
   A. Remove shroud covering flywheel

   B. Check air gap at trigger assembly and projection on the flywheel; set about .010 (± .005) (Figure 1)

   (NOTE: .010 will give the fastest starting. Be sure flat surfaces on trigger and projection are parallel to each other.)

CHECKING AIR GAP

FIGURE 1



   C. Retighten cap screws after gap is readjusted

   D. Remove high tension lead from terminal on coil

JOB SHEET #4

E. Insert one ohmmeter lead in coil terminal and the other to the coil mounting bracket (Figure 2)

(NOTE: Consult appropriate service manual for exact resistance.)

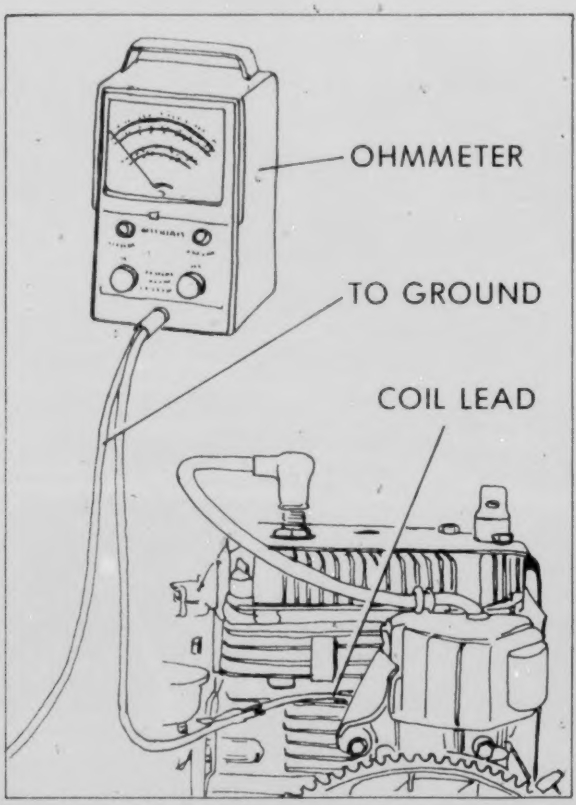


FIGURE 2

TESTING THE COIL

F. Connect one tester lead to the coil mounting bracket and the other to the ignition switch wire

(NOTE: Continuity should not be indicated here.)

G. Replace ignition coil assembly if wrong or widely varying results are obtained from either of these tests

H. Test the trigger module

1. Connect one tester lead to the AC inlet lead on trigger module and other to lead on trigger side of ignition switch

   (NOTE: This should show continuity in one direction but not the other; reverse leads to check this.)

JOB SHEET #4

2. Connect one tester lead to the trigger module mounting bracket and the other to the AC inlet lead to the module

   (NOTE: Continuity should be indicated in one direction but not the opposite; reverse leads to check this.)

3. Disconnect leads and remove trigger from the engine

4. Test with a flashlight type tester

   a. Connect one lead to the I terminal and the other to the trigger mounting bracket

   b. Lightly tap magnet with a metal object

      (NOTE: Light should come on and stay on until magnet is tapped again; this indicates that the SCR is operating properly.)

5. Reinstall trigger

6. Reset the air gap

   (NOTE: Replace the trigger module if wrong results are obtained from any of these tests.)

I. If ignition trouble persists after the system checks out in each of the preceding tests, the AC leads or ignition windings are probably faulty; replace stator assembly in this event

J. Have instructor evaluate work

K. Clean up work area and return tools to proper location

IGNITION SYSTEM
UNIT IX

JOB SHEET #5--CHECK IGNITION TIMING

I. Tools and materials

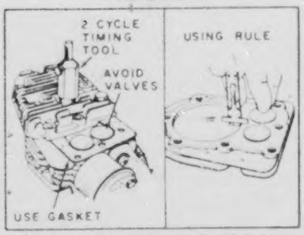
- A. Hand tool assortment
- B. Timing light
- C. Timing tool
- D. Continuity tester
- E. Safety glasses

II. Procedure

- A. Check ignition timing while engine is static
  1. Remove engine shroud and exterior parts
  2. Remove flywheel
  3. Adjust piston height at TDC using the manufacturer's specifications

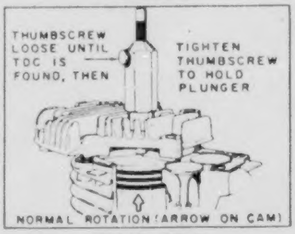
     (NOTE: If correct timing tool is not available, a straight edge and depth micrometer can be used. See Figures 1, 2, 3, 4, 5, and 6.)

FIGURE 1


2 CYCLE TIMING TOOL
AVOID VALVES
USE GASKET
USING RULE

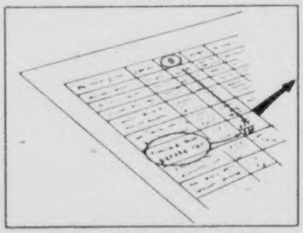
INSTALL TIMING TOOL OR RULE

FIGURE 2


THUMBSCREW LOOSE UNTIL TDC IS FOUND, THEN
TIGHTEN THUMBSCREW TO HOLD PLUNGER
NORMAL ROTATION (ARROW ON CAM)

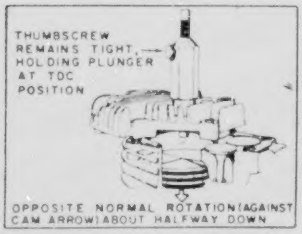
FIND TDC
(Top Dead Center)

FIGURE 3



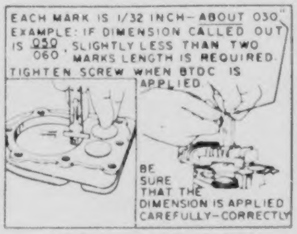
FIND BTDC TIMING DIMENSION (Specs.)

FIGURE 4


THUMBSCREW REMAINS TIGHT, HOLDING PLUNGER AT TDC POSITION
OPPOSITE NORMAL ROTATION (AGAINST CAM ARROW) ABOUT HALFWAY DOWN

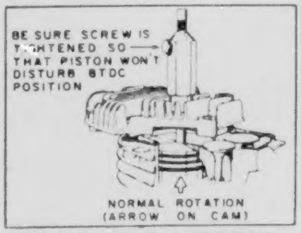
BACK OFF ROTATION
(Opposite Normal Running Rotation)

FIGURE 5


EACH MARK IS 1/32 INCH—ABOUT 030"
EXAMPLE: IF DIMENSION CALLED OUT IS 050/060, SLIGHTLY LESS THAN TWO MARKS LENGTH IS REQUIRED.
TIGHTEN SCREW WHEN BTDC IS APPLIED.
BE SURE THAT THE DIMENSION IS APPLIED CAREFULLY—CORRECTLY

APPLY DIMENSION TO TOOL

FIGURE 6


BE SURE SCREW IS TIGHTENED SO THAT PISTON WON'T DISTURB BTDC POSITION
NORMAL ROTATION (ARROW ON CAM)

BRING UP ON STROKE
(Normal Running Rotation)

JOB SHEET #5

4. Loosen the two stator adjustment bolts so the stator can be turned or rotated

5. Disconnect the coil lead to the points and connect one end of the continuity tester to the breaker point terminal (Figure 7)

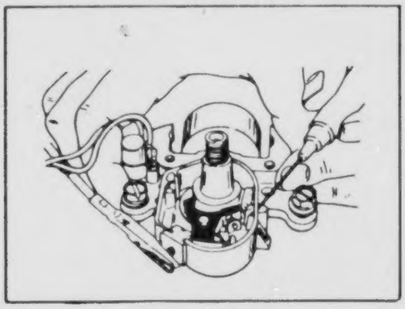


FIGURE 7

INSTALL TIMING LIGHT

6. Touch the other end of continuity tester to stationary breaker point

7. Rotate stator plate until test light goes out (Figure 8)

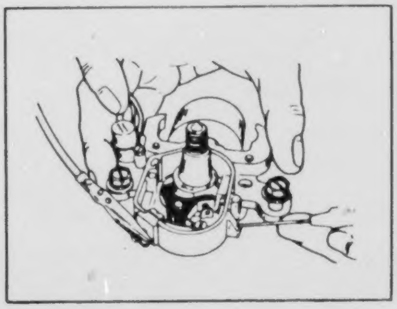


FIGURE 8

ROTATE STATOR UNTIL POINTS JUST OPEN

8. Carefully tighten stator adjustment bolts

9. Replace all coil wires, covers, and flywheel shrouds

B. Check ignition timing while engine is running

1. Connect timing light to high-tension lead between magneto and spark plug

2. Start engine and set engine RPM at manufacturer's specifications

(NOTE: This is usually between 1200-1800 RPM.)

JOB SHEET #5

3. Point flashing light at timing reference marks (Figure 9)

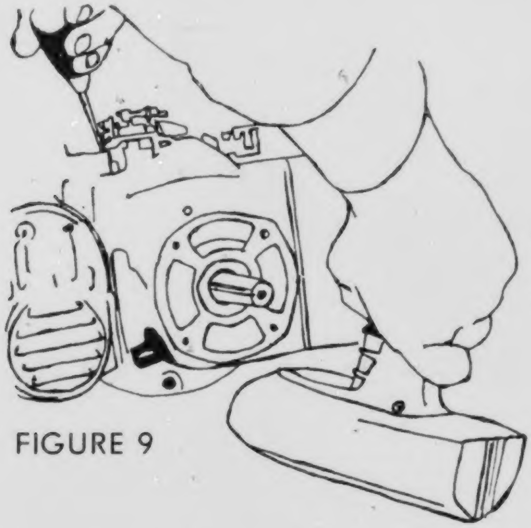


FIGURE 9

4. Check timing marks on case and flywheel for alignment

5. If timing marks need alignment, shift breaker point plate by loosening adjusting screw and shifting plate until marks are in alignment

6. Tighten all loose connections

C. Have instructor inspect work

D. Clean up work area and return tools to proper location

IGNITION SYSTEM
UNIT IX

NAME ______________________

TEST

1. State the purpose of the ignition system.

2. Match the types of ignition systems on the right to the correct descriptions.

______a. Produces current by magnetic induction for the primary ignition circuit without any outside source of electricity	1. Battery ignition system
______b. Uses semiconductors in place of one or more standard ignition components	2. Magneto ignition system
______c. Uses electronic parts in place of mechanically operated ignition points	3. Breakerless ignition system
______d. Uses battery to supply source of current for the primary ignition circuit	4. Solid state ignition system

3. Distinguish between the components of the primary and secondary battery ignition circuits by placing a "P" in front of the components in the primary ignition circuit and an "S" in front of those in the secondary ignition circuit.

______a. Resistance unit (resistor)

______b. Condenser

______c. Distributor cap

______d. Ignition switch

______e. Rotor

______f. Secondary winding

______g. High voltage wire

______h. Low voltage wire

______i. Contact points

______j. Battery

______k. Primary winding

______l. Spark plug

4. Identify the components of a magneto ignition system.

a. ____________

b. ____________

c. ____________

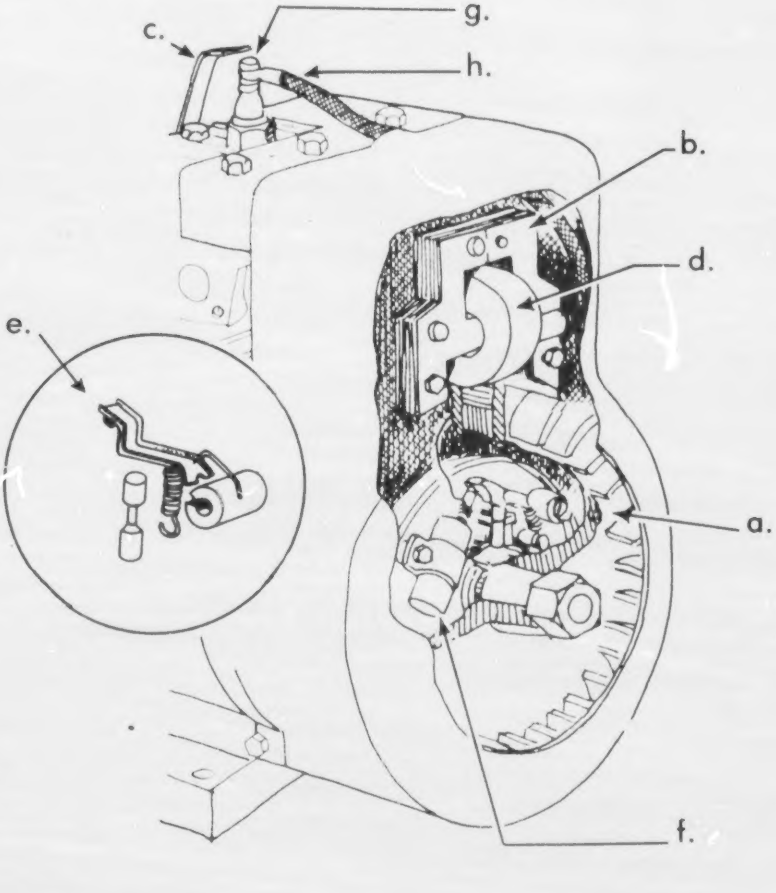
d. ____________

e. ____________

f. ____________

g. ____________

h. ____________



5. Identify the components of a solid state ignition system.

a. ____________

b. ____________

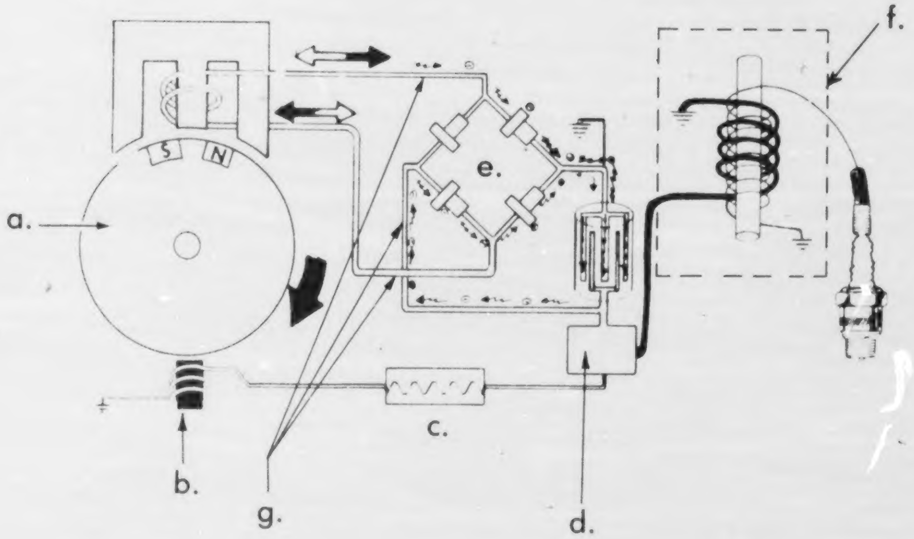
c. ____________

d. ____________

e. ____________

f. ____________

g. ____________



6. Identify the components of a breakerless ignition system.

a. ____________

b. ____________

c. ____________

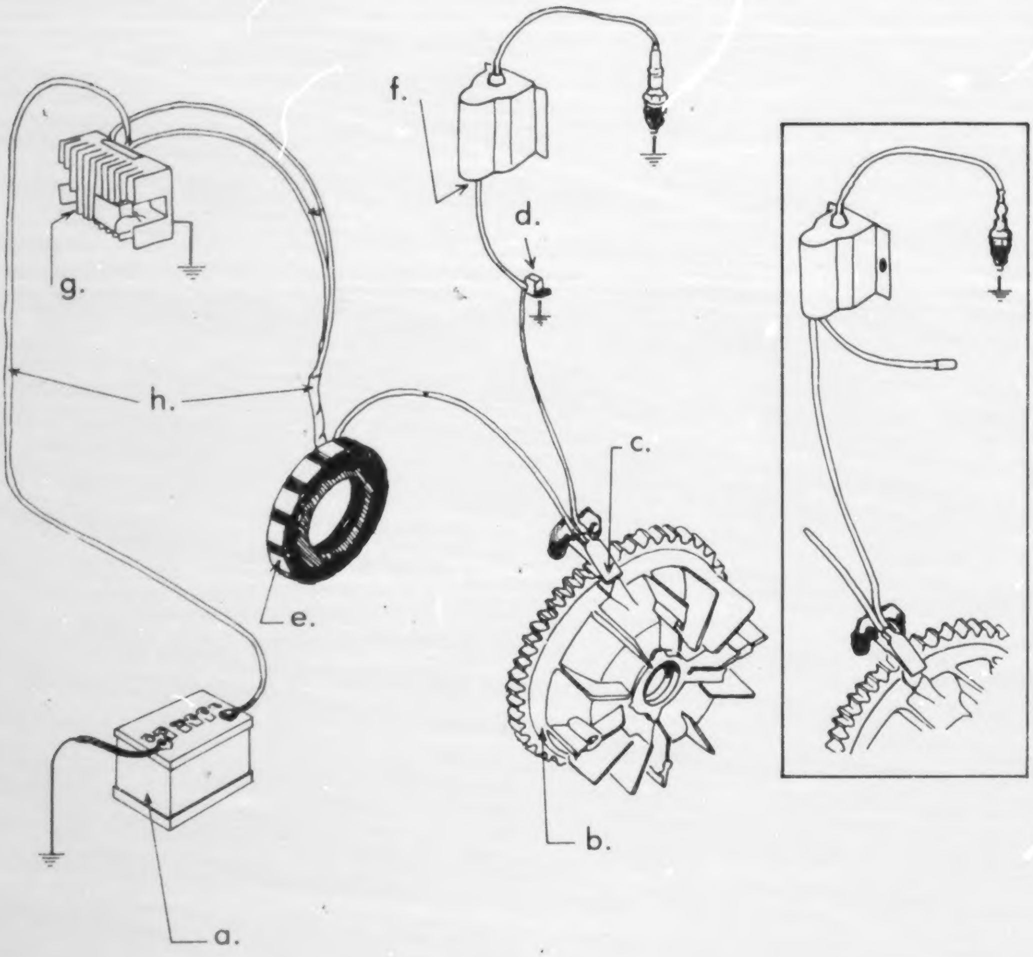
d. ____________

e. ____________

f. ____________

g. ____________

h. ____________



7. Match the components of the ignition system on the right to the correct purposes.

______a. Source of electrical power

______b. Opens and closes the primary circuit from the battery or coil to the contact points

______c. Transforms low voltage into high voltage necessary to jump the spark plug gap

______d. Make and break the primary circuit to allow the coil to produce high voltage at the spark plug

______e. Stores extra current as the contact points open to prevent arcing and burning

______f. Opens the contact points

______g. Changes alternating (AC) current to direct (DC) current

______h. Used in solid state ignition systems and operates like the condenser

______i. Generates a small amount of current that is used to activate the current from the capacitor

______j. Reduces voltage in the primary circuit to protect the contact points

______k. Provides a spark gap inside the engine cylinder to ignite the fuel-air mixture

______l. Carries low voltage from the battery or armature to the primary side of the ignition coil

______m. Carries high voltage from the secondary side of the coil to the spark plug

1. Trigger coil
2. Spark plug
3. Coil
4. Resistor
5. High voltage wire
6. Breaker cam
7. Battery
8. Diode rectifier
9. Contact points
10. Low voltage wire
11. Ignition switch
12. Capacitor
13. Condenser

8. Associate the operational steps with the ignition systems by placing an "X" in the appropriate blank(s).

	Battery	Magneto	Solid State	
a.	_____	_____	_____	With the ignition switch on and the contact points closed, low voltage current flows from the battery through the primary windings of the coil and through the contact points to ground
b.	_____	_____	_____	With the ignition switch on or the contact points closed, low voltage current is induced by magnets through the primary windings of the coil and through the contact points to ground
c.	_____	_____	_____	With the ignition switch on, low voltage current from the flywheel magnet induces alternating current (AC) in charge coil
d.	_____	_____	_____	The flow of low voltage current through the primary windings of the coil causes a magnetic field buildup
e.	_____	_____	_____	The AC current passes through a rectifier and changes to direct current (DC), which travels to the capacitor (condenser) where it is stored
f.	_____	_____	_____	As the contact points open, current attempts to continue to flow across the point surfaces; the condenser attached to the points absorbs this flow of current
g.	_____	_____	_____	The flywheel magnets pass the trigger coil and induce a small electrical charge, which turns on the silicon controlled rectifier (SCR)
h.	_____	_____	_____	Stopping the flow of current causes the magnetic field of the coil to collapse across the secondary coil windings, causing a high voltage surge
i.	_____	_____	_____	The high voltage surge is directed from the secondary windings of the coil through the distributor cap and rotor and on to the spark plug to ground

	Battery	Magneto	Solid State	
j.	______	______	______	The high voltage surge is directed from the secondary windings of the coil through the secondary wire on to the spark plug to ground
k.	______	______	______	The instantaneous discharge of energy induces a very high density magnetic field around the primary winding of the coil, which cuts the secondary winding and thus creates sufficient energy to fire the spark plug

9. Demonstrate the ability to:

   a. Remove, service, and replace spark plugs.

   b. Remove and replace contact points and condenser.

   c. Test the coil, condenser, armature, and flywheel magnets.

   d. Test and adjust a solid state ignition system.

   e. Check ignition timing.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

IGNITION SYSTEM
UNIT IX

ANSWERS TO TEST

1. Produces high voltage current to ignite the fuel-air mixture in the engine cylinder

2.
    a. 2
    b. 4
    c. 3
    d. 1

3.
    a. P
    b. P
    c. S
    d. P
    e. S
    f. S
    g. S
    h. P
    i. P
    j. P
    k. P
    l. S

4.
    a. Flywheel with magnets
    b. Armature
    c. Switch stop
    d. Coil
    e. Contact points
    f. Condenser
    g. Spark plug
    h. High voltage wire

5.
    a. Flywheel with magnets
    b. Trigger coil
    c. Resistor
    d. Transistorized rectifier (solid state switch)
    e. Diode rectifier

f. Ignition coil

g. Low voltage wire

6. a. Battery

b. Flywheel

c. Trigger module

d. Ignition switch

e. Alternator-stator

f. Ignition coil assembly

g. Rectifier-regulator

h. Low voltage wire

7. a. 7

b. 11

c. 3

d. 9

e. 13

f. 6

g. 8

h. 12

i. 1

j. 4

k. 2

l. 10

m. 5

8. a. Battery

b. Magneto

c. Solid State

d. Battery, Magneto

e. Solid State

f. Battery, Magneto

g. Solid State

h. Battery, Magneto

i. Battery

j. Magneto

k. Solid State

9. Performance skills evaluated to the satisfaction of the instructor

CHARGING SYSTEM
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to remove and replace, disassemble, check, and reassemble a generator and an alternator. This knowledge will be evidenced through demostration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the charging system to the correct definitions.
2. List two kinds of charging systems.
3. Match charging system components to the correct functions.
4. Identify the parts of a generator.
5. Match operating stages of the charging system to the correct functions.
6. Discuss the current flow in a basic generator.
7. Discuss how a generator converts AC to DC.
8. Match the external generator regulators to the correct functions.
9. Match the types of generators to the correct uses.
10. Identify the parts of the alternator system.
11. List two advantages of an alternator over a generator.
12. Discuss reverse polarity.
13. Demonstrate the ability to:
    a. Remove and replace a generator.
    b. Disassemble, check, and reassemble a generator.
    c. Remove and replace an alternator.
    d. Disassemble, check, and reassemble an alternator.

CHARGING SYSTEM
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss the procedures outlined in the job sheets.

  G. Provide examples of alternators and generators.

  H. Give test.

II. Student

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Charging System Components

    2. TM 2--Parts of the Generator

    3. TM 3--Current Flow in Basic Generator

4. TM 4--AC Converts to DC
5. TM 5--External Generator Regulator
6. TM 6--Types of Generators
7. TM 7--Parts of the Alternator Charging System

D. Job sheets

1. Job Sheet #1--Remove and Replace a Generator
2. Job Sheet #2--Disassemble, Check, and Reassemble a Generator
3. Job Sheet #3--Remove and Replace an Alternator
4. Job Sheet #4--Disassemble, Check, and Reassemble an Alternator

E. Test

F. Answers to test

II. References:

A. *Small Engines, Volume 1 and 2.* Athens, Georgia: American Association for Vocational Instructional Materials, 1974.

B. Armstrong, Ivan. *Auto Mechanics, Volume I.* Stillwater, Oklahoma: Oklahoma State Department of Vocational and Technical Education, 1976.

CHARGING SYSTEM
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Charging system--Recharges the battery and maintains a supply of electrical current to meet the operating needs of the engine and auxiliary circuits

B. Amp--Unit of measurement for electrical current

C. Volt--Unit of electrical pressure or force that will move a current of one ampere through a resistance of one ohm

D. Ohm--Standard unit for measuring resistance to flow of electrical current

E. Diode (rectifier)--Device that will allow current through itself in one direction and will block current in the opposite direction

F. Short circuit--Wire touching another wire and providing a shorter path for current to flow

G. Open circuit--Circuit in which a wire is broken or disconnected

H. Grounded circuit--Circuit in which a wire touches ground causing the current to flow to ground instead of through the circuit

I. Armature--Series of wire conductors in the form of a loop rotating in a stationary magnetic field

J. Commutator--Bars on end of armature drive shaft and connected to the ends of each wire conductor wound on armature

K. Pole shoes--Permanent magnets that are fixed to the inside of the generator housing and set opposite each other to create a weak magnetic field

L. Field circuit--One wire conductor wound around both poles many times and attached to the brush

M. Regulator--Assembly which houses the cut-out relay, voltage regulator, and current regulator

N. Arcing--Current attempting to cross between the commutator sections and the brush

INFORMATION SHEET

O. Polarity--Direction of current flow through the generator

(NOTE: Generator circuits need to be polarized after servicing.)

P. "A" circuit--Regulator circuit with supply voltage to the generator field, then through the regulator to ground

Q. "B" Circuit--Regulator is between the battery and generator field windings

II. Kinds of charging systems

(NOTE: Both circuits generate an alternating current, but differ in how they rectify the alternating current to direct current.)

A. Direct current

(NOTE: Direct current charging systems are associated with generator type systems.)

B. Alternating current

(NOTE: Alternating current charging systems are associated with alternator type systems.)

III. Charging system components and functions (Transparency 1)

A. Battery

1. Starts the circuit by supplying spark to start engine
2. Helps out during peak operation when electrical loads are too much for generator or alternator

B. Generator or alternator

1. Supplies electrical power to accessory circuits
2. Recharges battery

C. Regulator

1. Opens and closes the charging circuit (cut-out relay)
2. Prevents overcharging of battery (voltage regulator)
3. Limits the generator's output to safe rates (current regulator)

D. Ammeter--Measures the rate of current flow

INFORMATION SHEET

IV. Parts of a generator (Transparency 2)

   A. Brush holder

   B. Brushes

   C. Brush cover strap

   D. Commutator end cover

   E. Brush holder mounting plate

   F. Commutator

   G. Frame

   H. Armature

   I. Pole shoes

   J. Field coils

   K. Thru bolts

   L. Drive end plate

   M. Drive gear

      (NOTE: The drive may be a belt and pully instead of a gear.)

   N. Bearings

      (NOTE: These may be anti-friction or plain bearings.)

V. Operating stages of charging system

   A. Starting--Battery supplies all load current

   B. Peak operation--Battery helps generator supply current

   C. Normal operation--Generator supplies all current and recharges battery

VI. Current flow in basic generator (Transparency 3)

(NOTE: Armature rotates through the magnetic field of the poles generating voltage.)

   A. Voltage flows from armature loop to the commutator ring

      (NOTE: The left end of the armature loop is positive while the right end is negative.)

INFORMATION SHEET

B. Voltage flows from the commutator ring through brushes to a wire connected to a load

C. Current flows when circuit is complete

VII. How a generator converts AC to DC (Transparency 4)

A. Commutator is split in two parts creating a gap as the commutator passes the brushes

(NOTE: This is called the static neutral point where no voltage is created.)

B. Past this point the other half of the commutator contacts the brushes reversing the current flow

C. At the same time the rotating armature reverses its polarity converting AC to DC

VIII. Functions of the external generator regulators (Transparency 5)

A. Cut-out relay--Automatic switch which closes when generator is running and opens when generator stops to prevent battery discharge

B. Voltage regulator--Controls the amount of voltage the regulator produces through a shunt coil and contact points controlling the strength of the magnetic field; prevents overheating

C. Current regulator--Controls the current flow similar to the voltage regulator

(NOTE: Both the voltage regulator and the current regulator are used but while one is working, the other is not.)

IX. Types and uses of generators (Transparency 6)

A. Shunt--Used as a standard generator for most normal operations

B. Third brush--Eliminates the use of a current regulator, is relatively easy to change third brush position and control the output, and is used in systems with low speed and low load requirements

C. Interpole--Provides a better commutation point and extends brush life

D. Bucking field--Used where there is a wide variation of load and speed requirements

E. Split field--Used in systems with low speed, but high load requirements

INFORMATION SHEET

X. Parts of the alternator system (Transparency 7)

   A. Alternator coil (stator)

   B. Flywheel

   C. Ceramic ring

   D. Rectifier

   E. Battery

XI. Advantages of an alternator over a generator

   A. Produces higher output at low and idle engine speeds

   B. Provides simplicity in construction which requires less maintenance

XII. Reverse polarity

   A. Generator polarity is opposite that of the battery

   B. Battery is in series with the generator

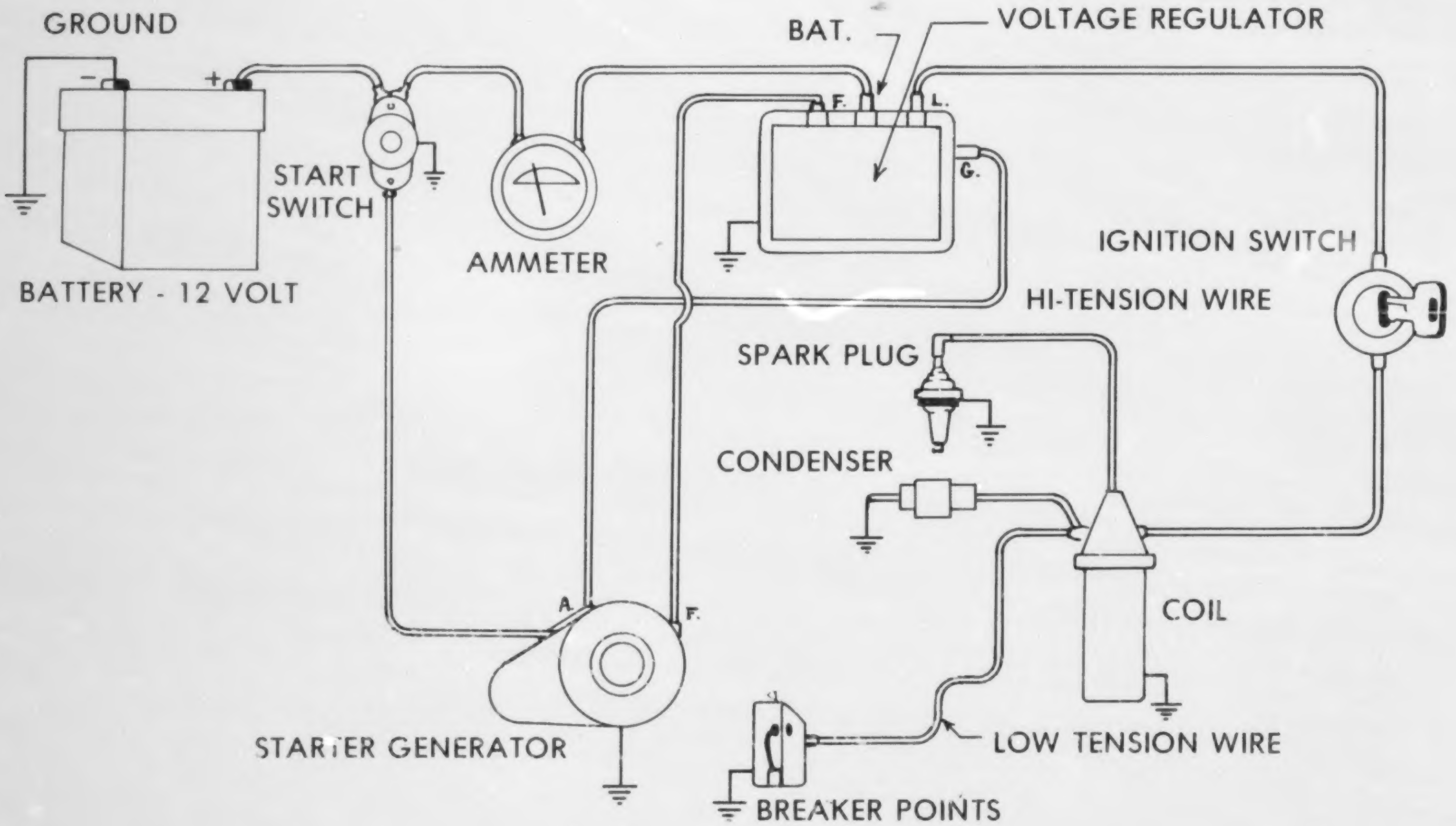
   C. Generator builds up voltage and closes the cut-out relay points

   D. High voltage can create enough current and heat to weld the points together

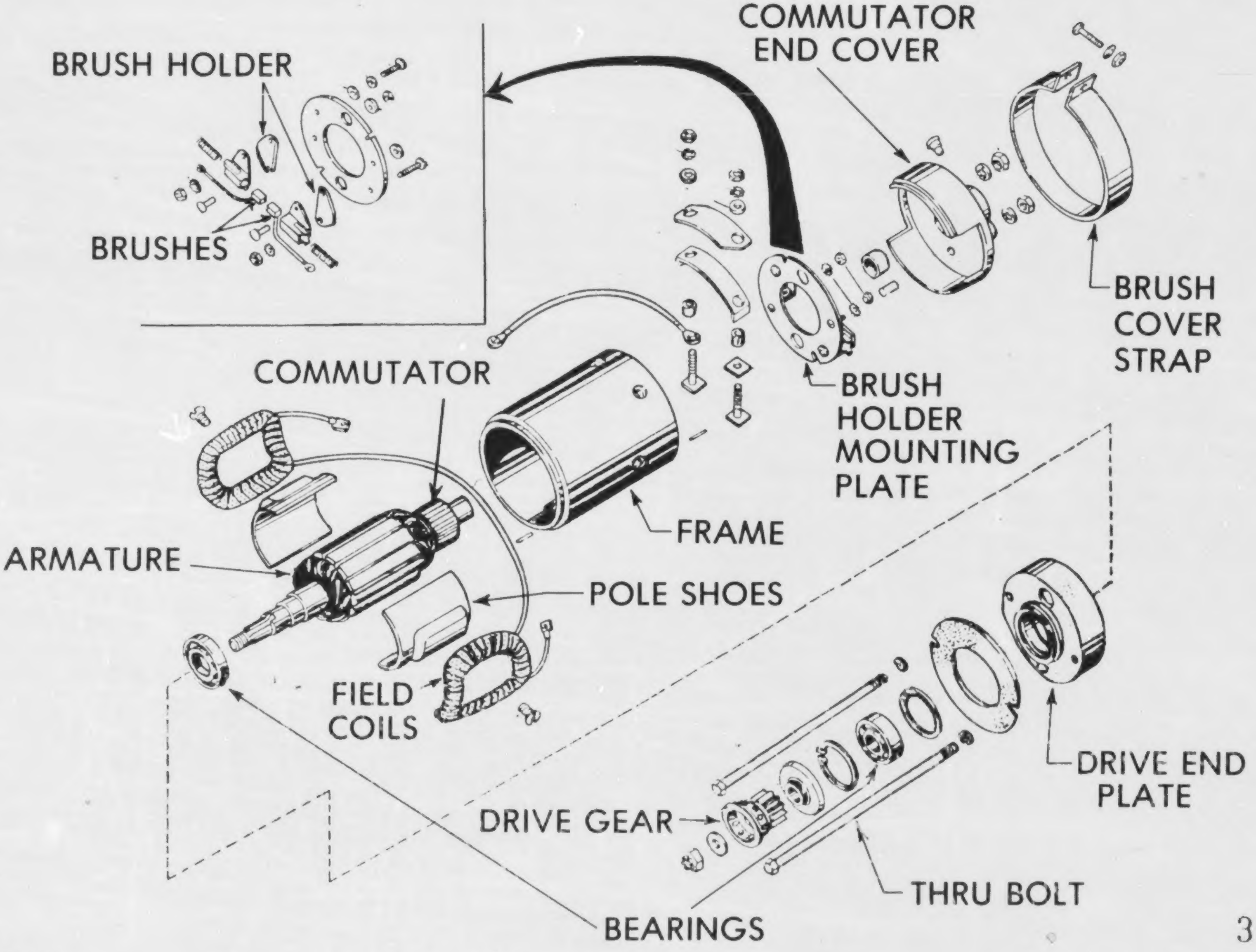
   (CAUTION: After any service polarize the DC generator.)

   (NOTE: Pole shoe polarity is determined by the magnetism of the field coils the last time current passed through the coils; a slight current through the field coils when servicing can accidentally change pole polarity.)

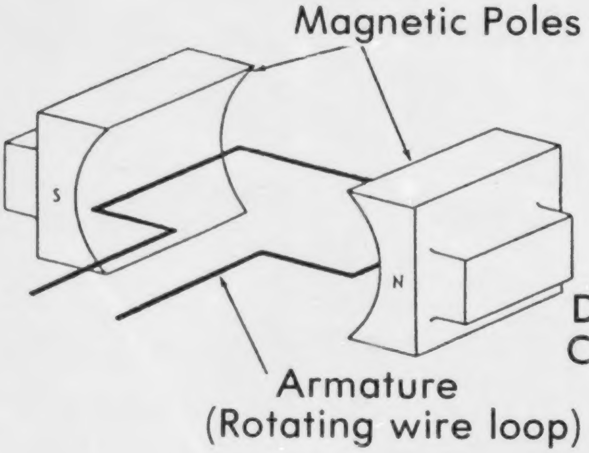
CHARGING SYSTEM COMPONENTS


GROUND
BATTERY - 12 VOLT
START SWITCH
AMMETER
BAT.
F.
L.
G.
VOLTAGE REGULATOR
IGNITION SWITCH
HI-TENSION WIRE
SPARK PLUG
CONDENSER
COIL
A.
F.
STARTER GENERATOR
LOW TENSION WIRE
BREAKER POINTS

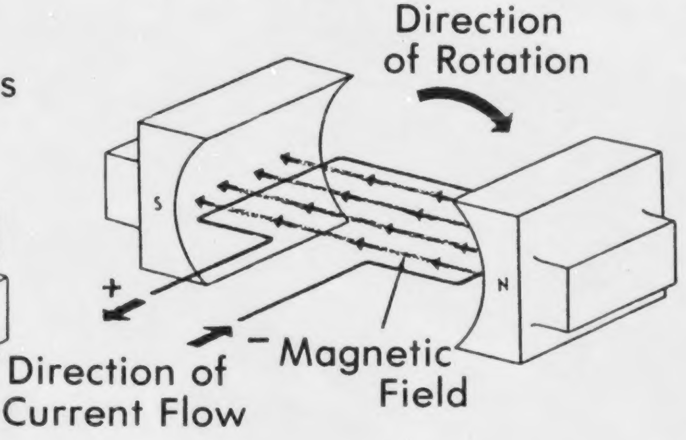
PARTS OF A GENERATOR


BRUSH HOLDER
BRUSHES
COMMUTATOR END COVER
BRUSH COVER STRAP
BRUSH HOLDER MOUNTING PLATE
COMMUTATOR
FRAME
ARMATURE
POLE SHOES
FIELD COILS
DRIVE END PLATE
DRIVE GEAR
THRU BOLT
BEARINGS

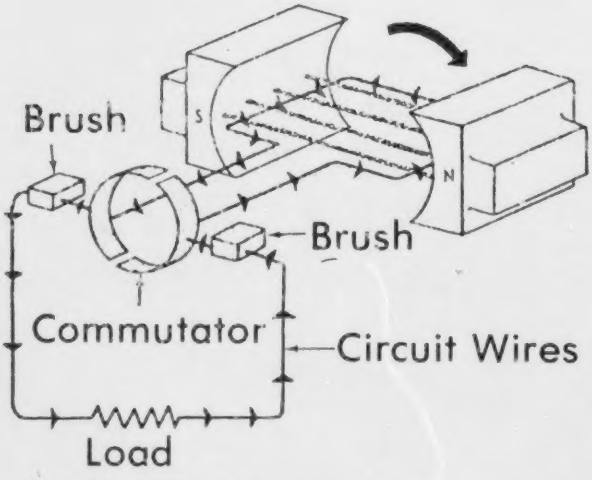
CURRENT FLOW IN BASIC GENERATOR


Magnetic Poles
S
N
Armature
(Rotating wire loop)

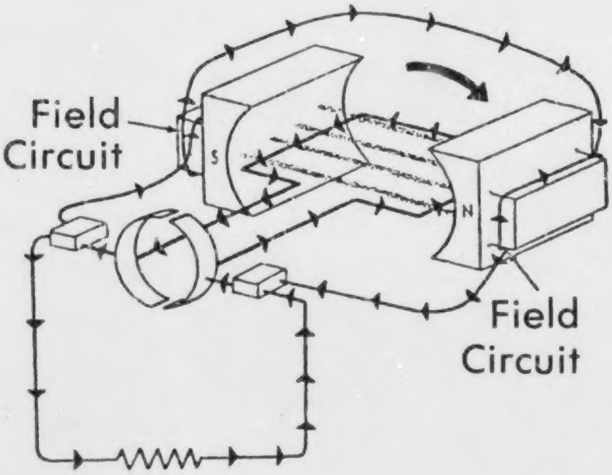
THE BASIC PARTS
OF A GENERATOR


Direction
of Rotation
S
N
+
−
Direction of
Current Flow
Magnetic
Field

BASIC GENERATED VOLTAGE

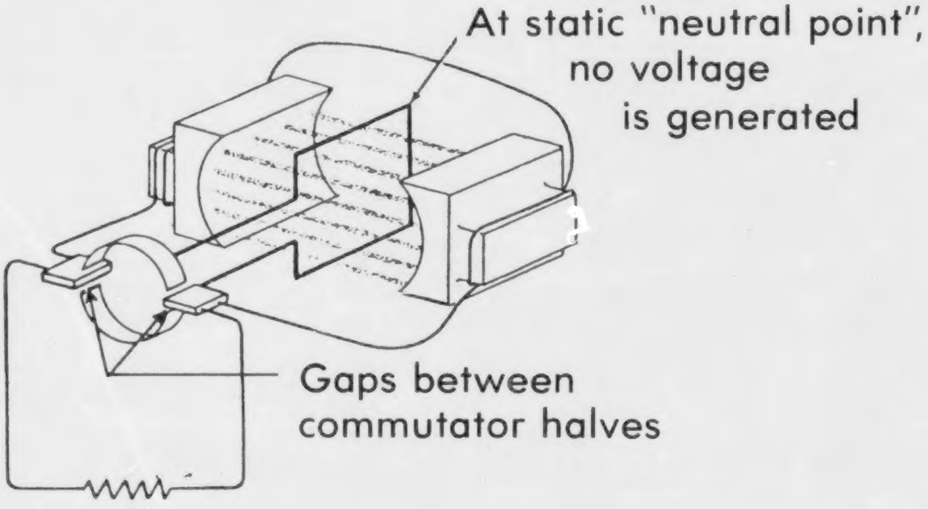

Brush
S
N
Brush
Commutator
Circuit Wires
Load

BASIC CURRENT FLOW
IN GENERATOR

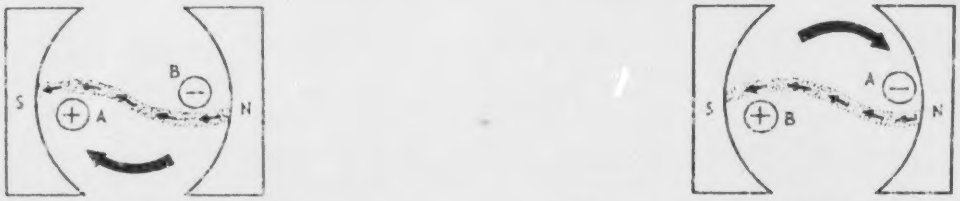

Field
Circuit
S
N
Field
Circuit

COMPLETE PARTS
OF BASIC GENERATORS

AC CONVERTS TO DC


At static "neutral point", no voltage is generated
Gaps between commutator halves

HOW GENERATOR CONVERTS AC TO DC CURRENT



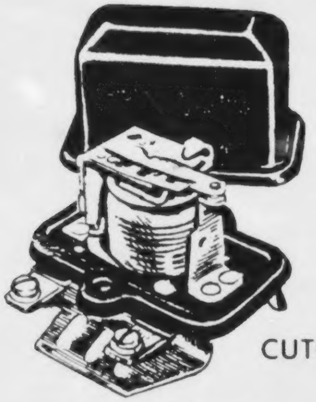
First Half of Revolution

Second Half of Revolution

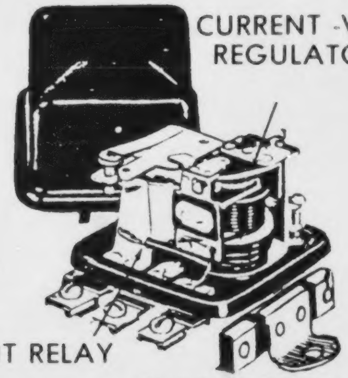
HOW THE POLARITY OF THE ARMATURE CHANGES DURING EACH REVOLUTION

EXTERNAL GENERATOR REGULATOR

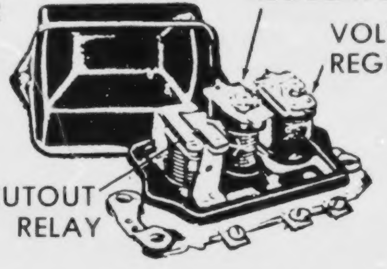
GENERATOR REGULATORS - THREE TYPES



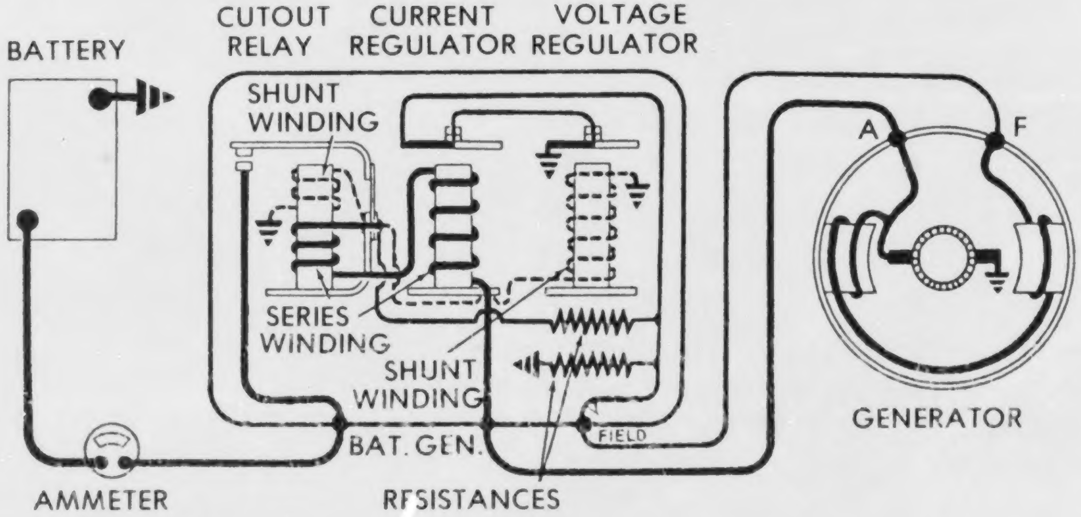
CUTOUT RELAY


CURRENT -VOLTAGE REGULATOR
CUTOUT RELAY

CUTOUT RELAY
CURRENT - VOLTAGE
REGULATOR

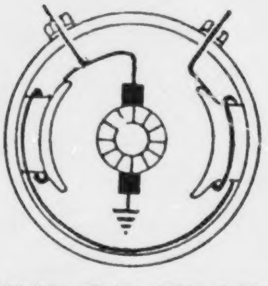

CURRENT REGULATOR
VOLTAGE REGULATOR
CUTOUT RELAY

CUTOUT RELAY,
CURRENT REGULATOR
AND VOLTAGE REGULATOR

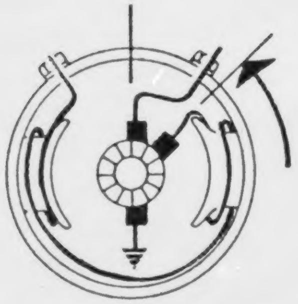

BATTERY
CUTOUT RELAY
CURRENT REGULATOR
VOLTAGE REGULATOR
SHUNT WINDING
SERIES WINDING
SHUNT WINDING
A
F
GENERATOR
FIELD
BAT. GEN.
AMMETER
RESISTANCES

OPERATION OF ALL THREE GENERATOR REGULATOR UNITS

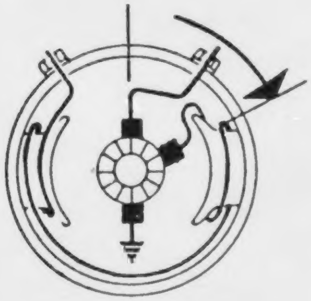
TYPES OF GENERATORS



SHUNT GENERATOR



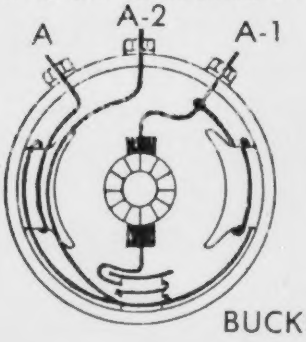
Higher Output

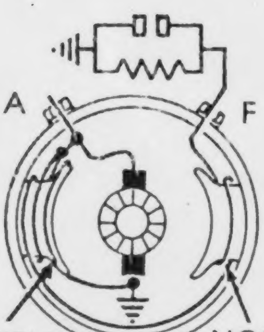


Lower Output

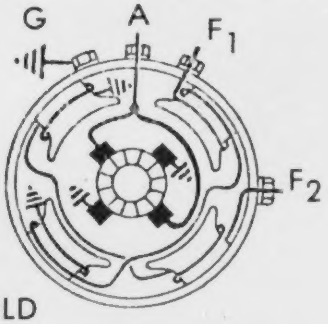
THIRD BRUSH GENERATOR

INTERPOLE GENERATOR



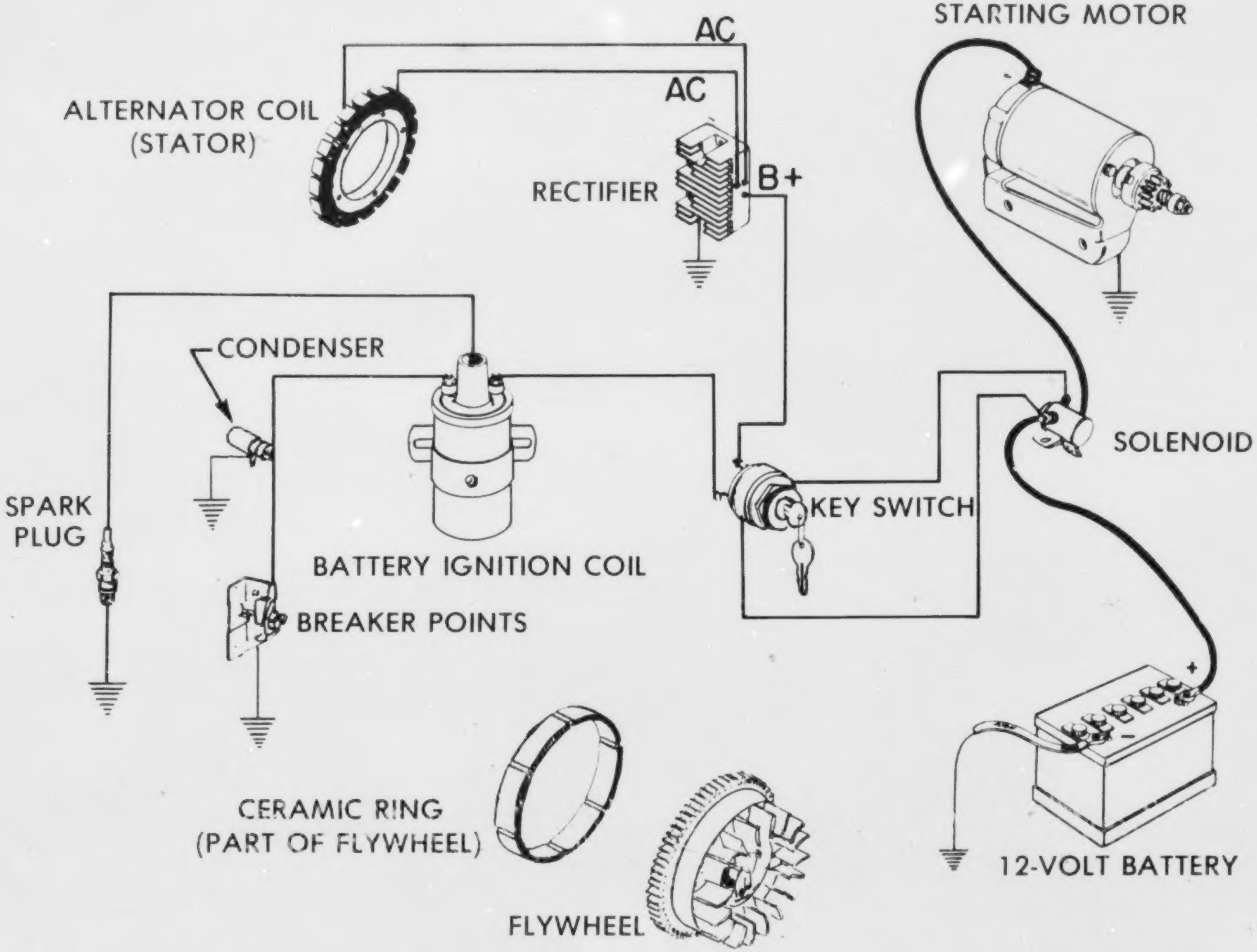

A
F
BUCKING FIELD
NORMAL FIELD

SPLIT FIELD GENERATOR



BUCKING FIELD GENERATOR

PARTS OF THE ALTERNATOR CHARGING SYSTEM


AC
AC
STARTING MOTOR
ALTERNATOR COIL (STATOR)
RECTIFIER
B+
CONDENSER
SOLENOID
SPARK PLUG
KEY SWITCH
BATTERY IGNITION COIL
BREAKER POINTS
+
−
CERAMIC RING (PART OF FLYWHEEL)
12-VOLT BATTERY
FLYWHEEL

CHARGING SYSTEM
UNIT III

JOB SHEET #1--REMOVE AND REPLACE A GENERATOR

I. Tools and materials

A. Hand tool assortment

B. Suitable pry bar

C. Belt tension gauge

D. Generator test stand

(NOTE: Use any suitable equipment for spinning generator to check operation.)

E. Safety glasses

II. Procedure

A. Remove generator

1. Remove the leads from the generator terminals (Figure 1)

(NOTE: You may want to tag the leads to ensure that you put them back in the same position.)

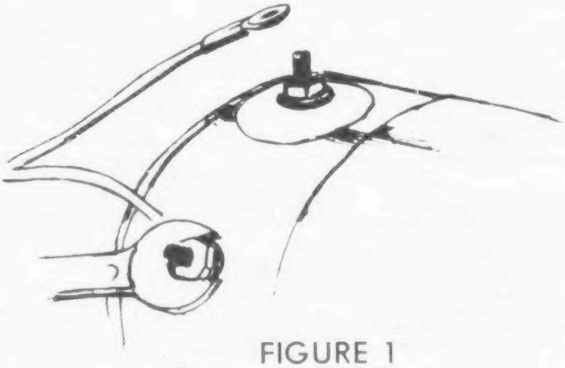


FIGURE 1

2. Remove the generator belt adjusting bolt from the generator

3. Move the generator toward the engine (Figure 2)

JOB SHEET #1

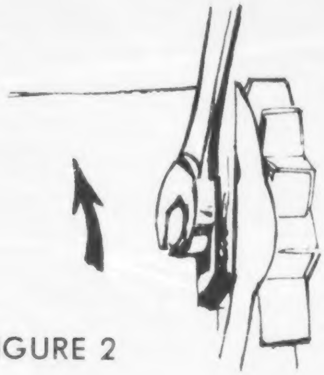


FIGURE 2

4. Remove the generator belt from the generator pulley

5. Remove the bolts holding the generator to the engine mounting bracket (Figure 3)

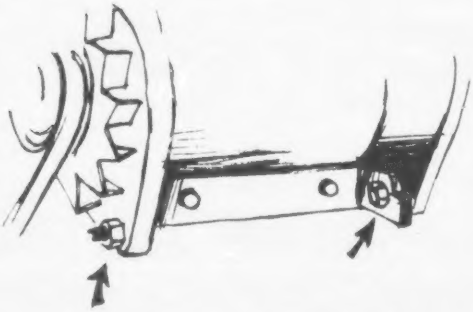


FIGURE 3

6. Lift the generator out of the bracket

7. Service the generator as required

JOB SHEET #1

B. Replace generator

1. Position the generator in the engine mounting bracket
2. Start generator retaining bolts and tighten securely
3. Position generator belt on pulley and move generator away from engine to tighten belt
4. Install generator adjusting bolt
5. Pry the generator away from engine to adjust generator belt and tighten adjustment bolt
6. Check generator belt tension with a belt tension gauge and adjust to manufacturer's specifications (Figure 4)

   (NOTE: The generator belt must be adjusted properly)

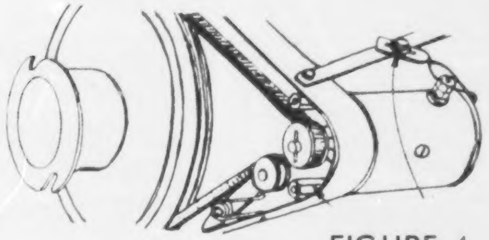
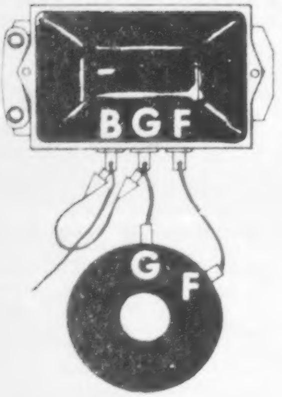


FIGURE 4

7. Install wire leads that were removed from generator
8. Before starting engine, polarize the generator

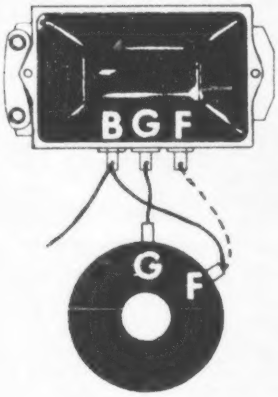
   (NOTE: Polarize "A" circuit generators by holding one end of a jumper wire against the regulator BAT terminal; scratch the other end of the jumper wire on the regulator ARM or GEN terminals. Polarize "B" circuit generators by removing the lead from the FIELD terminal of the regulator. Strike (or momentarily touch) the F-lead to the BAT terminal of the regulator. See Figures 5 and 6.)

JOB SHEET # 1



"A" CIRCUIT

FIGURE 5



"B" CIRCUIT

FIGURE 6

CHARGING SYSTEMS
UNIT III

JOB SHEET #2-DISASSEMBLE, CHECK, AND REASSEMBLE A GENERATOR

I. Tools and materials

   A. Basic hand tool set

   B. Growler

   C. Test lamp or volt-ohmmeter

   D. Generator pulley puller

   E. Ball bearing grease

   F. Hacksaw blade

   G. Spring tension gauge

   H. Shop towels

   I. Safety glasses

II. Procedure

   A. Disassemble generator

   (NOTE: Scribe generator case before separating.)

      1. Remove generator thru bolts (Figure 1)

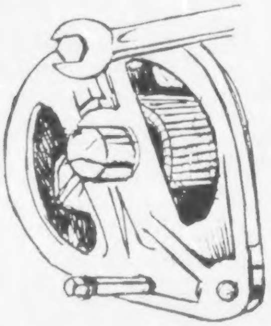


FIGURE 1

      2. Lightly tap the generator commutator end frame and remove from housing

JOB SHEET #2

3. Remove the drive end frame and armature assembly from the generator housing (Figure 2)

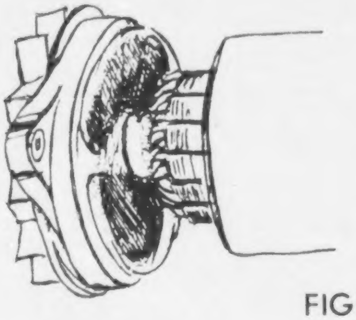


FIGURE 2

4. Remove the generator brushes (Figure 3)

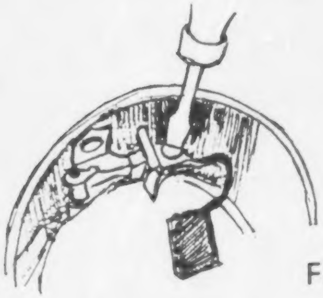


FIGURE 3

JOB SHEET #2

5. Place the armature and drive end frame assembly in a vise (Figure 4)

   (CAUTION: Use brass jaws on vise.)

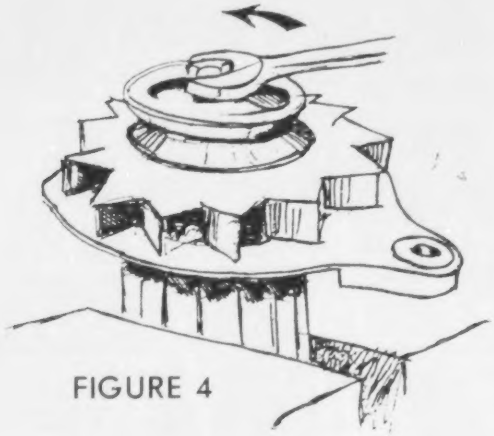


FIGURE 4

6. Remove the pulley nut

7. Remove the pulley from the armature using a pulley puller as required (Figure 5)

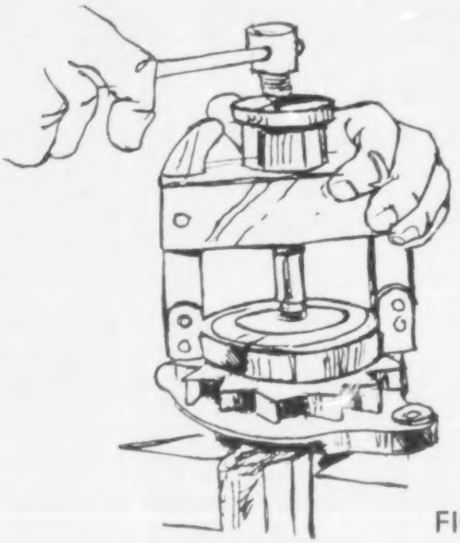


FIGURE 5

JOB SHEET #2

8. Slide the drive end frame and spacer columns off armature shaft
9. Remove armature from vise
10. Remove bearing retainer and gasket from drive end frame
11. Remove drive end bearing from drive end frame

B. Service and check generator

1. Clean all generator components

   (NOTE: Do not wash the fields or armature with a degreasing solvent.)

2. Inspect generator drive end frame bearings for roughness or scored races
3. Inspect generator brush holders to see if they are bent or deformed; check generator brush springs for proper spring tension
4. Check fit of armature shaft in bushing in commutator end frame

   (NOTE: If bushing is excessively worn, the end frame should be replaced.)

5. Inspect armature commutator for roughness or out-of-round

   (NOTE: If armature commutator is rough or out-of-round, it should be turned or serviced on an armature turning lathe.)

JOB SHEET #2

6. Test armature for shorts (Figure 6)

   a. Place the armature on a growler and turn on

   b. Rotate the armature while holding a hacksaw blade over the armature core

   (NOTE: If the blade vibrates, the armature is shorted and will require replacement.)

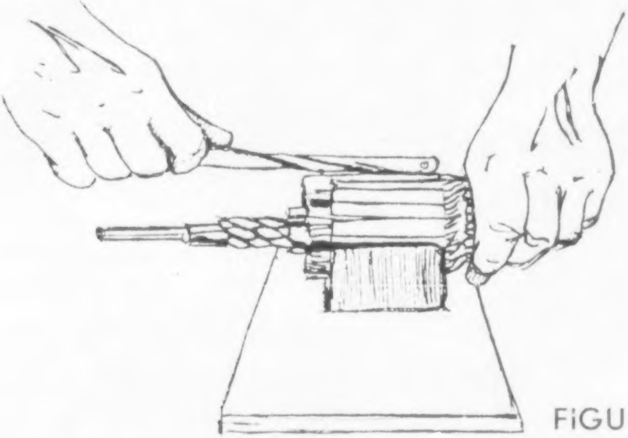


FIGURE 6

7. Test armature for ground (Figure 7)

   a. Place one lead of a test lamp on the armature core or shaft

   b. Touch second lead to the commutator segments on the commutator

   c. Rotate the lead around the commutator, being certain to touch all segments

(NOTE: If the lamp lights, the armature is grounded and will require replacement.)

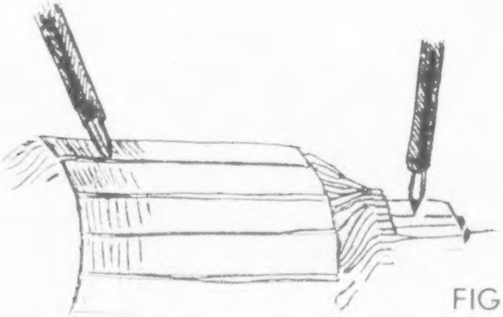


FIGURE 7

JOB SHEET #2

8. Test armature for open

   a. Place one lead on a commutator segment

   b. Place the other lead on the segment common with it

   (NOTE: On a two brush generator they will be 180° apart. Light should burn between these common segments.)

   c. Proceed around commutator until all segments have been checked

9. Test field coil for open circuit (Figure 8)

   a. Place one lead of a test lamp on field terminal

   b. Place the other lead on the end of the field coil lead through the armature terminal

   (NOTE: If lamp does not light, the fields are open and must be replaced.)

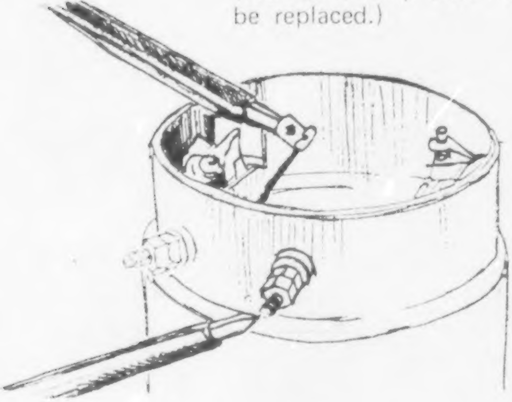


FIGURE 8

10. Test field coil for ground ("A" circuit only) (Figure 9)

   a. Place one lead of a test lamp on generator housing

   b. Place the other lead on field terminal

   (NOTE: If lamp lights, the field coils are grounded and must be repaired or replaced.)

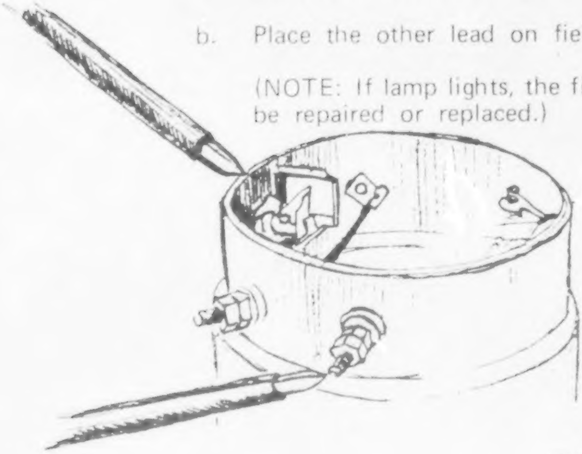


FIGURE 9

JOB SHEET #2

11. Check insulated brush holder for ground (Figure 10)
    a. Place one lead of a test lamp on brush holder
    b. Place the other lead on the generator housing

    (NOTE: If lamp lights, insulated brush is grounded and must be repaired.)

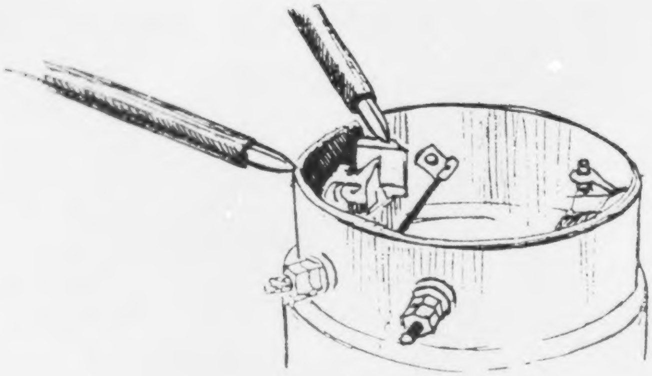


FIGURE 10

12. Inspect all parts for wear or damage
13. Replace all damaged or worn parts

C. Reassemble generator

1. Pack the generator ball bearings with high melting point ball bearing grease
2. Install the ball bearing in the drive end frame

   (NOTE: Make sure gasket is in place and retainer screws tightened securely.)

3. Install the drive end frame and bearing assembly onto armature shaft

   (NOTE: Make sure ball bearing spacers are in place if used.)

JOB SHEET #2

4. Install ball bearing spacers, fan, pulley, and retaining nut
5. Tighten retaining nut securely
6. Install new brushes in brush holders and push brushes back against spring tension (Figure 11)

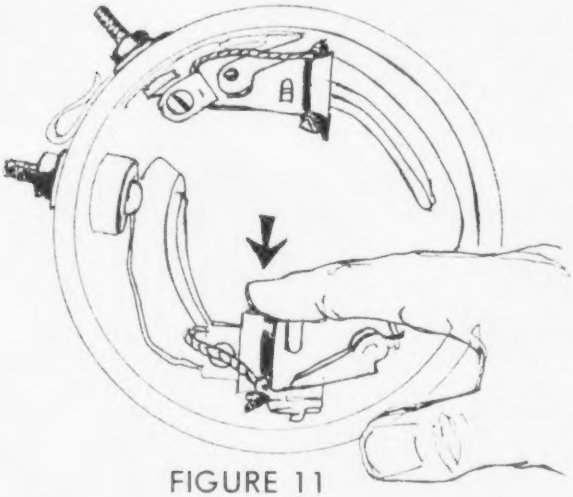


FIGURE 11

7. Install armature and drive end frame assembly into generator housing
8. Release brushes so they will contact commutator
9. Assemble commutator end frame over end of armature shaft
10. Rotate both end frames until dowels engage, then start thru bolts

    (NOTE: Check match marks to make sure they line up.)

11. Tighten thru bolts securely
12. Check generator operation before replacing on vehicle
    a. Perform output test of "A" circuit

       (NOTE: Connect generator for spinning and output test.)

       1) Remove field wire from terminal and ground to frame

JOB SHEET #2

2) Connect voltmeter from armature terminal to frame

3) Spin generator in correct direction

4) Check reading on voltmeter

(NOTE: Compare to manufacturer's specification.)

b. Perform output test of "B" circuit

1) Connect jumper wire from field terminal to armature terminal

2) Connect "+" ammeter lead to armature terminal

3) Connect "-" ammeter lead to positive side of battery

4) Rotate generator

5) Take reading

(NOTE: Compare to manufacturer's specifications.)

(CAUTION: Disconnect battery leads as soon as test is over to prevent overheating.)

CHARGING SYSTEM
UNIT III

JOB SHEET #3--REMOVE AND REPLACE AN ALTERNATOR

I. Tools and materials

  A. Hand tool assortment

  B. Flywheel removal tools

  C. Shop towels

  D. Safety glasses

II. Procedure

  A. Remove engine shroud or blower housing

  B. Remove flywheel

  (NOTE: Check magnets on flywheel for small metal chips and remove them.)

  C. Check correct location of stator wires

  D. Remove stator bolts and spacers

  E. Remove rectifier bolt

  F. Remove stator and rectifier as a unit

  G. Replace rectifier

  H. Replace stator

  (NOTE: Hold stator toward screws to take up clearance in mounting bushing.)

  I. Install flywheel

  (NOTE: Check stator wire location so they do not rub the flywheel.)

  J. Replace blower housing

  K. Start engine and check alternator output

CHARGING SYSTEMS
UNIT III

JOB SHEET #4-DISASSEMBLE, CHECK AND REASSEMBLE AN ALTERNATOR

I. Tools and materials

  A. Hand tool assortment

  B. Ammeter

  C. Test lamp

  D. Flywheel removal tools

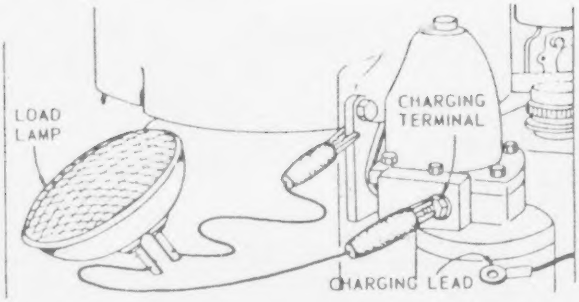
  E. Safety glasses

II. Procedure

  A. Run tests

    1. Test output (Figure 1)

FIGURE 1



      a. Disconnect charging lead from charging terminal

      (NOTE: Do not allow terminal on charging lead to touch engine or equipment.)

      b. Clip 12 volt load lamp between charging terminal and ground

      c. Start engine

      (NOTE: If lamp lights, alternator is functioning; if lamp does not light, alternator is defective.)

JOB SHEET #4

2. Test stator (Figure 2)

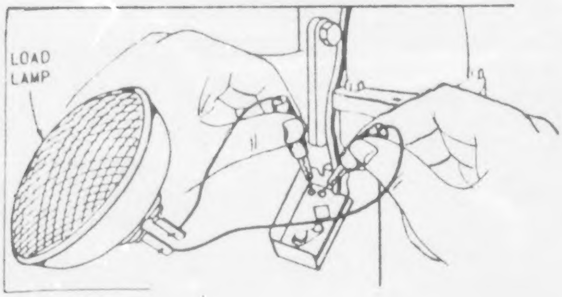


FIGURE 2

   a. Disconnect charging lead from battery and rectifier

   b. Remove rectifier box mounting screw

   c. Rotate box to expose eyelets to which red and black stator leads are soldered

      (NOTE: Charging lead terminal must not touch engine.)

   d. Start engine

   e. Touch load lamp leads to eyelets with engine running

      (NOTE: If load lamp lights, the stator is satisfactory; if load lamp does not light, stator or flywheel is defective.)

3. Check flywheel and stator

   a. Remove blower housing and flywheel and check to be sure magnet ring is in place and has magnetism

      (NOTE: Replace flywheel if needed.)

   b. Check charging lead to be sure there is a good connection to the positive (+) battery terminal

   c. If flywheel or charging lead are not defective, replace stator

JOB SHEET #4

4. Replace defective stator (Figure 3)

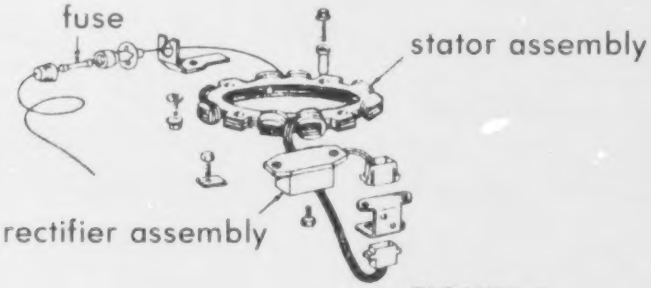

fuse
stator assembly
rectifier assembly

FIGURE 3

a. Remove flywheel

(NOTE: Be sure to note correct location of stator wires.)

b. Remove two stator mounting screws and bushings

c. Remove rectifier box from stator assembly

d. Install stator

e. Torque screws to correct specifications

f. Install rectifier box connecting leads correctly

g. Replace flywheel and blower housing and run engine to check output

B. Test system

1. Test half-wave rectifier (Figure 4)

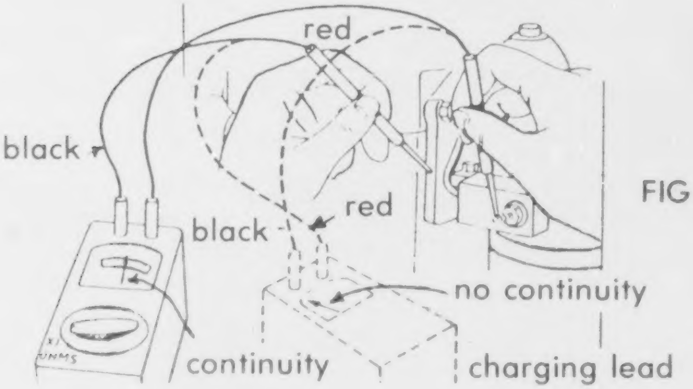

red
black
black
red
no continuity
continuity
charging lead

FIGURE 4

JOB SHEET #4

a. Do not run engine

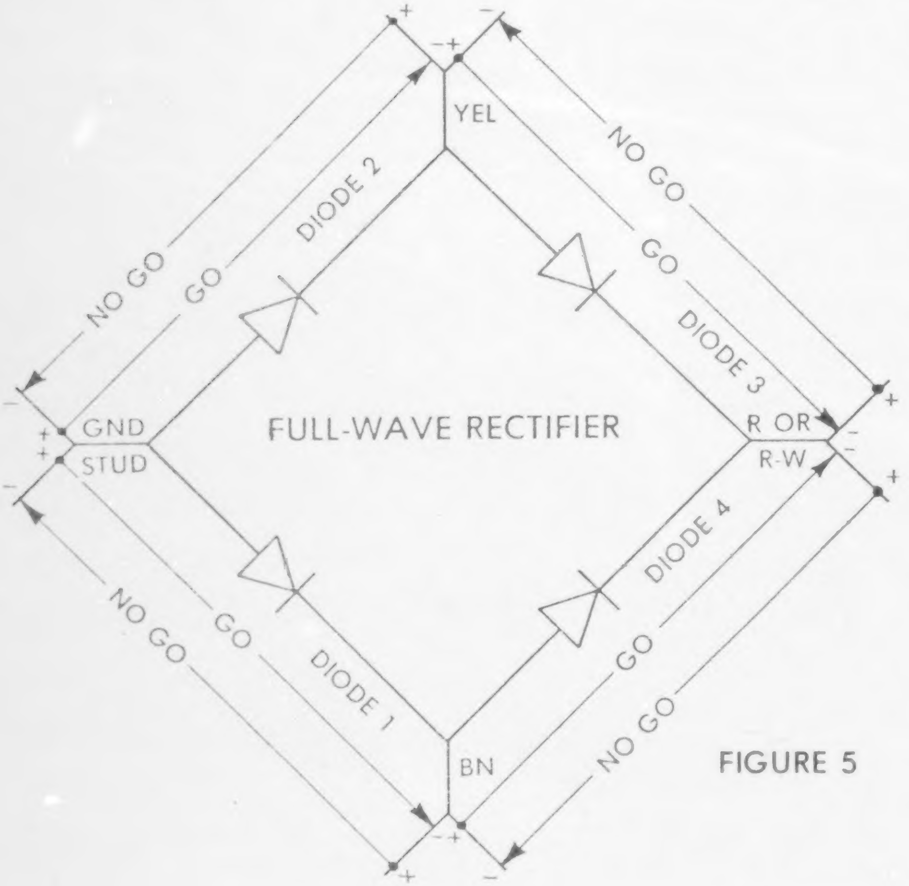
b. Use a multimeter to test resistance from charging terminal to ground

c. Reverse test leads and recheck

(NOTE: One way there should be a meter reading and the other way there should not be a meter reading. The actual meter readings are not important. If the meter shows a reading both ways or neither way, then the rectifier is defective.)

2. Bench test full-wave rectifier with ohmmeter

(NOTE: The bridge or full-wave rectifier consists of 4 diodes, and each one must be tested individually. See Figure 5.)



FULL-WAVE RECTIFIER
YEL
GND
STUD
R OR
R-W
BN
DIODE 1
DIODE 2
DIODE 3
DIODE 4
GO
NO GO
+
−

FIGURE 5

JOB SHEET #4

a. Connect the positive (+) lead of the ohmmeter to the ground stud and the negative (-) lead of the ohmmeter to the brown (common) terminal on diode #1

(NOTE: The meter should show a low resistance, meaning the current will flow ("GO") in that direction.)

b. Reverse the ohmmeter leads, negative (-) lead to the ground stud and positive (+) lead to the brown (common) terminal on diode #1

(NOTE: There should be a very high resistance reading, meaning current will not flow ("NO GO") in that direction; a low or high resistance reading in both directions indicates a faulty rectifier.)

c. Repeat the procedure for each of the remaining diodes

(NOTE: Since color coding varies with different makes and models, the appropriate service manual should be consulted to identify the rectifier terminals.)

3. Test full-wave rectifier with voltmeter (Figure 6)

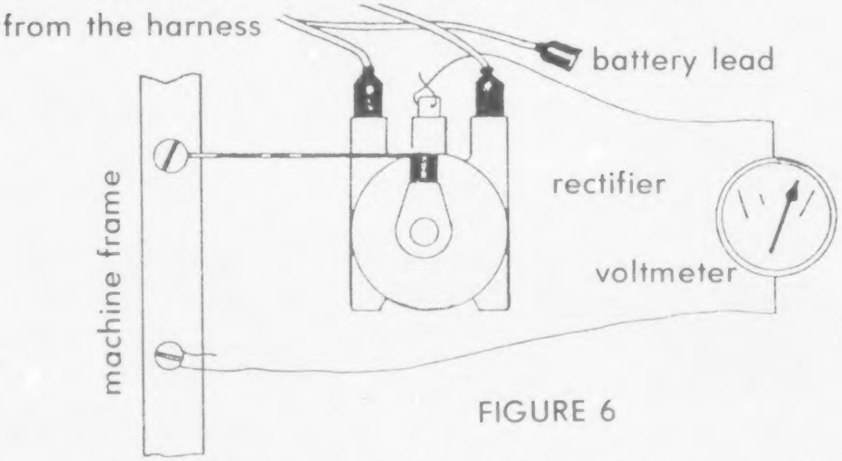


FIGURE 6

a. Disconnect the rectifier to battery lead at the rectifier terminal

b. Connect the voltmeter from the rectifier terminal to a good ground

c. Start the engine and increase the speed to approximately 3,000 RPM

(NOTE: The voltmeter should read about 7 volts for a 6 volt system and 14 volts for 12 volt system; a low reading indicates a faulty rectifier.)

JOB SHEET #4

4. Replace defective half-wave rectifier (Figure 7)
    a. Remove rectifier from engine or starter motor
    b. Pry off fiber board exposing soldered connections between rectifier and stator leads (Figure 7)
    c. Cut stator leads close to eyelets (Figure 8)

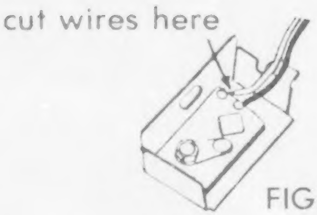

cut wires here

FIGURE 7

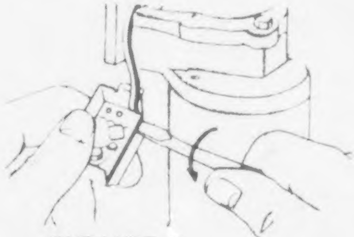


FIGURE 8

    d. Strip insulation back 3/8" on stator leads
    e. Discard defective rectifier box
    f. Solder on new rectifier leads to stator leads
    g. Wrap solder and splices carefully with tape (Figure 9)

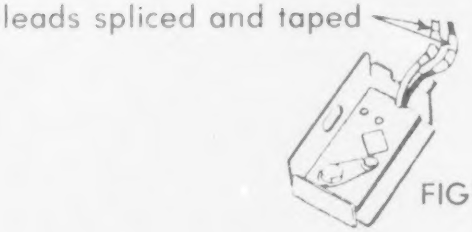

leads spliced and taped

FIGURE 9

    h. Fold leads into rectifier box and mount on starter or engine (Figures 10 and 11)

(NOTE: Wires should not rub on flywheel.)

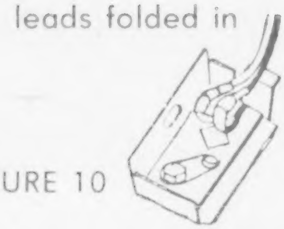

leads folded in

FIGURE 10

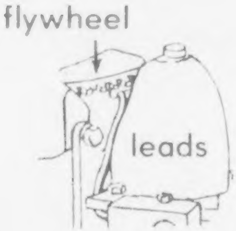

flywheel
leads

FIGURE 11

JOB SHEET #4

i. Install flywheel and blower housing

j. Check output

CHARGING SYSTEM
UNIT III

NAME________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Unit of measurement for electrical current

_____b. Unit of electrical pressure or force that will move a current of one ampere through a resistance of one ohm

_____c. Standard unit for measuring resistance to flow of electrical current

_____d. Device that will allow current through itself in one direction and will block current in the opposite direction

_____e. Wire touching another wire and providing a shorter path for current to flow

_____f. Circuit in which a wire is broken or disconnected

_____g. Circuit in which a wire touches ground causing the current to flow to ground instead of through the circuit

_____h. Recharges the battery and maintains a supply of electrical current to meet the operating needs of the engine and auxiliary circuits

_____i. Current attempting to cross between the commutator sections and the brush

_____j. Series of wire conductors in the form of a loop rotating in a stationary magnetic field

_____k. Regulator is between the battery and generator field windings

1. Open circuit
2. Arcing
3. Ohm
4. "A" Circuit
5. Charging system
6. Armature
7. Grounded circuit
8. Commutator
9. Short circuit
10. Pole shoes
11. Diode (rectifier)
12. Field circuit
13. Volt
14. Polarity
15. Amp
16. "B" Circuit
17. Regulator

______l. Permanent magnets that are fixed to the inside of the generator housing and set opposite each other to create a weak magnetic field

______m. Assembly which houses the cut-out relay, voltage regulator, and current regulator

______n. Direction of current flow through the generator

______o. One wire conductor wound around both poles many times and attached to the brush

______p. Bars on end of armature drive shaft and connected to the ends of each wire conductor wound in armature

______q. Regulator circuit with supply voltage to the generator field then, through the regulator to ground

2. List two kinds of charging systems.

a.

b.

3. Match the charging system components on the right to the correct functions.

______a. Supplies electrical power to accesory circuits and recharges battery

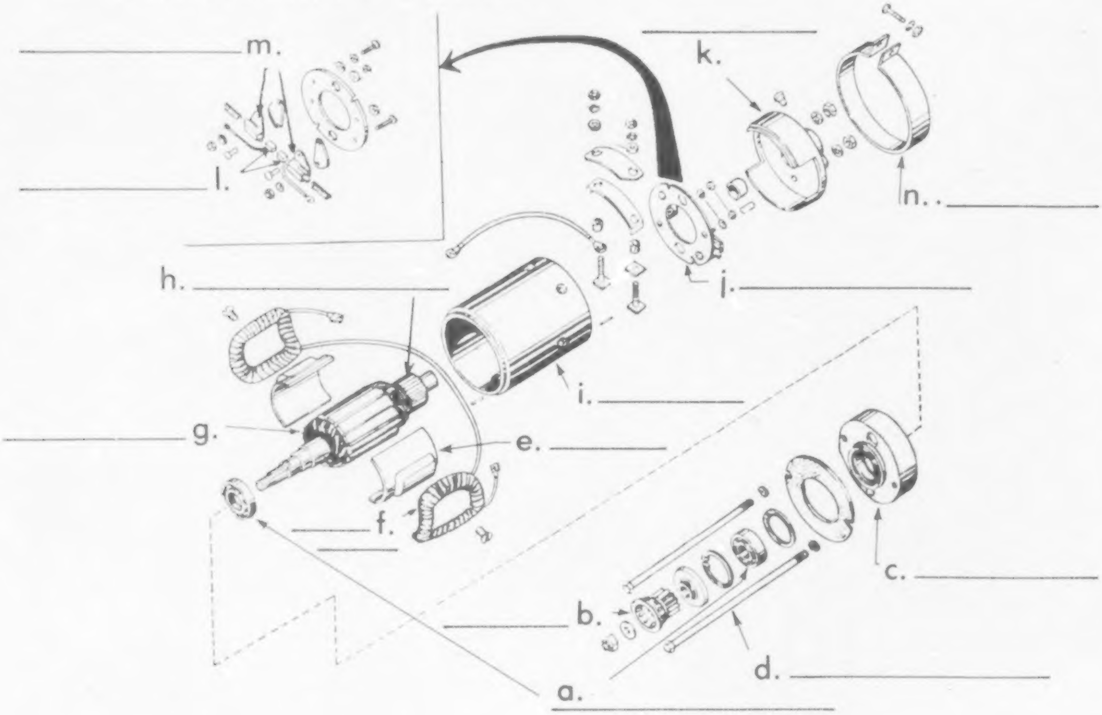
______b. Measures the rate of current flow

______c. Opens and closes the charging circuit (cut-out relay), prevents overcharging of battery (voltage regulator), and limits the generator's output to safe rates (current regulator)

______d. Starts the circuit by supplying spark to start engine and helps out during peak operation when electrical loads are too much for generator or alternator

1. Regulator
2. Ammeter
3. Battery
4. Generator or alternator

4. Identify the parts of a generator.



5. Match the operating stages of the charging system on the right to the correct functions.

_____a. Battery helps generator supply current
_____b. Generator supplies all current and recharges battery
_____c. Battery supplies all load current

1. Starting
2. Peak operation
3. Normal operation

6. Discuss the current flow in a basic generator.

7. Discuss how a generator converts AC to DC.

8. Match the external generator regulators on the right to the correct functions.

_____a. Controls the current flow similar to the voltage regulator

_____b. Controls the amount of voltage the regulator produces through the shunt coil and contact points controlling the strength of the magnetic field; prevents overheating

_____c. Automatic switch which closes when generator is running and opens when generator stops to prevent battery discharge

1. Cut-out relay
2. Current regulator
3. Voltage regulator

9. Match the types of generators on the right to the correct uses.

_____a. Used as a standard generator for most normal operations

_____b. Eliminates the use of a current regulator, is relatively easy to change third brush position and control the output, and is used in systems with low speed and low load requirements

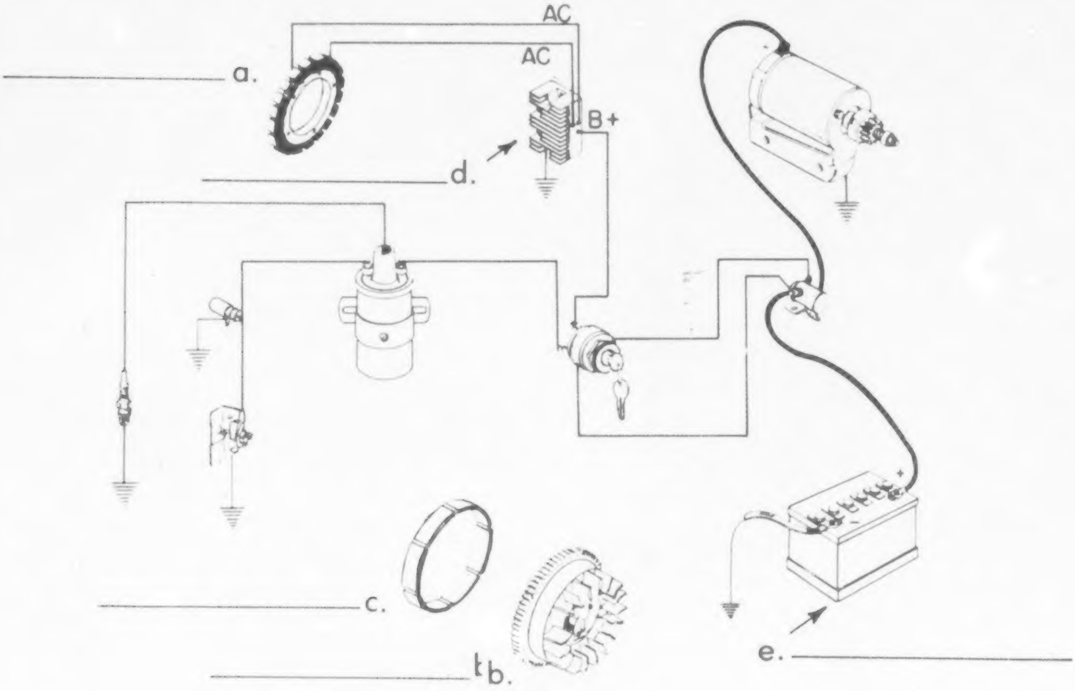
_____c. Provides a better commutation point and extends brush life

_____d. Used where there is a wide variation of load and speed requirements

_____e. Used in systems with low speed, but high load requirements

1. Bucking field
2. Shunt
3. Split field
4. Interpole
5. Third brush

10. Identify the parts of the alternator system.



11. List two advantages of an alternator over a generator.

a.

b.

12. Discuss reverse polarity.

13. Demonstrate the ability to:

    a. Remove and replace a generator.

    b. Disassemble, check, and reassemble a generator.

    c. Remove and replace an alternator.

    d. Disassemble, check, and reassemble an alternator.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

CHARGING SYSTEM
UNIT III

ANSWERS TO TEST

1. a. 15
   b. 13
   c. 3
   d. 11
   e. 9
   f. 1
   g. 7
   h. 5
   i. 2
   j. 6
   k. 16
   l. 10
   m. 17
   n. 14
   o. 12
   p. 8
   q. 4

2. a. Direct current
   b. Alternating current

3. a. 4
   b. 2
   c. 1
   d. 3

4. a. Bearings
   b. Drive gear
   c. Drive end plate
   d. Thru bolts
   e. Pole shoes
   f. Field coils
   g. Armature
   h. Commutator
   i. Frame
   j. Brush holder mounting plate
   k. Commutator end cover
   l. Brushes
   m. Brush holder
   n. Brush cover strap

5. a. 2
   b. 3
   c. 1
6. Discussion should include:
   a. Voltage flows from armature loop to the commutator ring
   b. Voltage flows from the commutator ring through brushes to a wire connected to a load
   c. Current flows when circuit is complete
7. Discussion should include:
   a. Commutator is split in two parts creating a gap as the commutator passes the brushes
   b. Past this point the other half of the commutator contacts the brushes reversing the current flow
   c. At the same time the rotating armature reverses its polarity converting AC to DC
8. a. 2
   b. 3
   c. 1
9. a. 2
   b. 5
   c. 4
   d. 1
   e. 3
10. a. Alternator coil (stator)
    b. Flywheel
    c. Ceramic ring
    d. Rectifier
    e. Battery

11. a. Produces higher output at low and idle engine speeds
    b. Provides simplicity in construction which requires less maintenance

12. Discussion should include:
    a. Generator polarity is opposite that of the battery
    b. Battery is in series with the generator
    c. Generator builds up voltage and closes the cut-out relay points
    d. High voltage can create enough current and heat to weld the points together

13. Performance skills evaluated to the satisfaction of the instructor

STARTING SYSTEMS
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to remove and replace a starter and disassemble, check, and reassemble a starter. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with starting systems to the correct definitions.
2. Identify the types of small gas engine starters.
3. Match components of the mechanical starting system to the correct functions.
4. Match components of the DC starting system to the correct functions.
5. Identify the main parts of a DC wound field starter.
6. Identify the main parts of a DC starter generator.
7. Identify the types of starter drives.
8. Demonstrate the ability to:
    a. Remove, disassemble, test, service, and reassemble a starter.
    b. Replace starter rewind spring.

STARTING SYSTEMS
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Provide examples of different types of starters and starter drives.

   H. Identify parts of a twelve volt starter.

   I. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Types of Starters

      2. TM 2--Types of Starters (Continued)

   3. TM 3--Parts of the DC Wound Field Starter

   4. TM 4--Parts of a DC Starter Generator

   5. TM 5--Types of Starter Drives

F. Job sheets

   1. Job Sheet #1--Remove, Disassemble, Test, Service, Reassemble and Replace a Starter

   2. Job Sheet #2--Replace Starter Rewind Spring

G. Test

H. Answers to test

II. References:

A. Armstrong, Ivan. *Auto Mechanics, Volume I.* Stillwater, Oklahoma: Oklahoma State Department of Vocational and Technical Education, 1976.

B. *Small Engines, Volume II,* 3rd ed. Athens, Georgia: American Association for Vocational Instructional Materials, 1974.

STARTING SYSTEMS
UNIT IV

INFORMATION SHEET

I. Terms and definitions

   A. Starter--Device which converts mechanical or electrical power into rotating motion for cranking engine

   B. Starter frame--Housing which connects and contains starter component parts

   C. Armature--Main shaft in starter, composed of commutator segments, windings, and bushing or bearing journals

   D. Brushes--Sliding contacts which transfer electrical energy to commutator

   E. Starter drive pinion--Gear that meshes with flywheel to crank engine

   F. Pole shoes-Ends of magnets in the field frame of a starting motor

   G. Field coils--Wire wrapped around pole pieces to increase the strength of the magnetic field when current is applied

   H. Safe interlock (neutral interlock)--Safety device which allows engine to be started in neutral only

   I. Solenoid--Electromagnetic device which produces a reciprocating motion for remote control of starting circuit

II. Types of small gas engine starters (Transparencies 1 and 2)

   A. Rope-wind

   B. Rope-rewind

   C. Wind up

   D. Electric (AC and DC)

III. Components of mechanical starting system

   A. Starter housing--Cover for the starter mechanism

   B. Recoil spring--Used to automatically rewind the starter rope after each starting attempt

   C. Pulley--Housing for pawls that lock to crankshaft adapter to crank engine

INFORMATION SHEET

D. Engaging pawl--Locks pulley to crankshaft adapter on starting pull of rope

E. Pawl spring--Returns pawl to neutral position during rewind cycle

IV. Components of DC starting system

A. Battery--Source of electrical power

B. Key switch--Device which activates the starter motor switch

C. Starter motor switch--Switch which closes the high amperage circuit from battery to starter

D. Starter motor--Drives the flywheel to crank the engine

E. Switch wire--Conductor that carries a low amount of current to energize the starter motor switch

F. Battery cables--Conductors which carry large amounts of current to complete the starter circuit

V. Parts of the DC wound field starter (Transparency 3)

A. Thru bolt

B. Commutator end cap assembly

C. Drive end frame

D. Starter frame

E. Armature

F. Positive brushes

G. Starter drive pinion

H. Wound field coils

I. Commutator

VI. Parts of a DC starter generator (Transparency 4)

A. Thru bolt

B. Brush holders

C. Commutator frame end

D. Frame

E. Field coil

INFORMATION SHEET

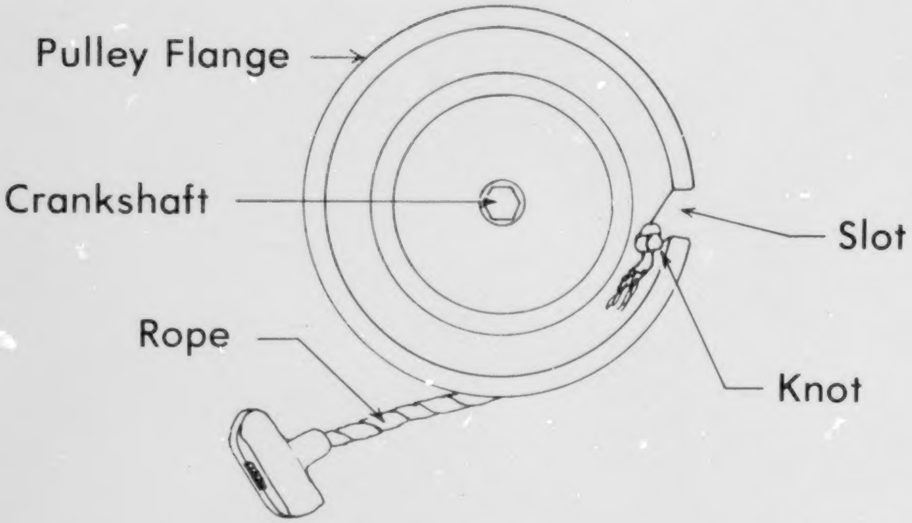
- F. Pole shoe
- G. Insulator
- H. Armature
- I. Drive end frame

VII. Types of starter drives (Transparency 5)

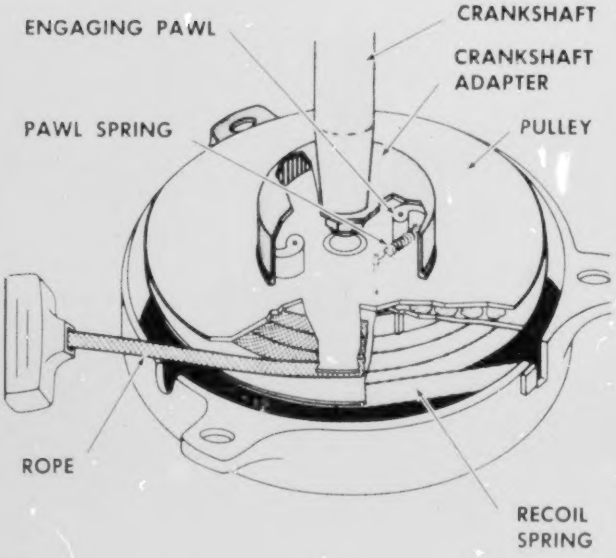
- A. Cone drive
- B. Split pulley drive
- C. Bendix drive

TYPES OF STARTERS

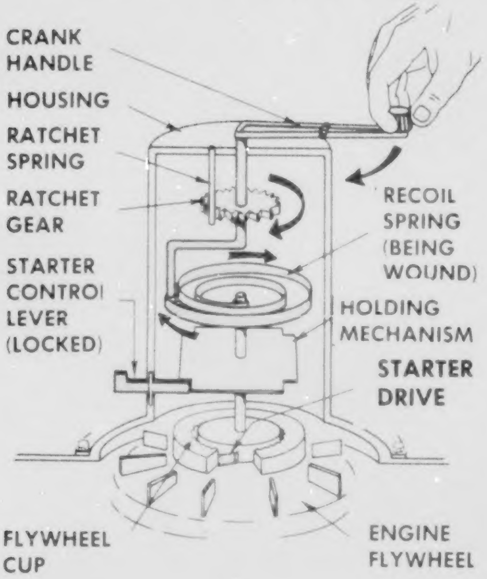
ROPE WIND

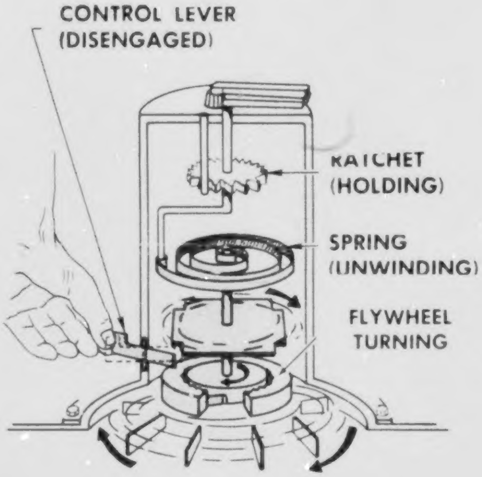

Pulley Flange
Crankshaft
Slot
Rope
Knot

ROPE REWIND


ENGAGING PAWL
CRANKSHAFT
CRANKSHAFT ADAPTER
PAWL SPRING
PULLEY
ROPE
RECOIL SPRING

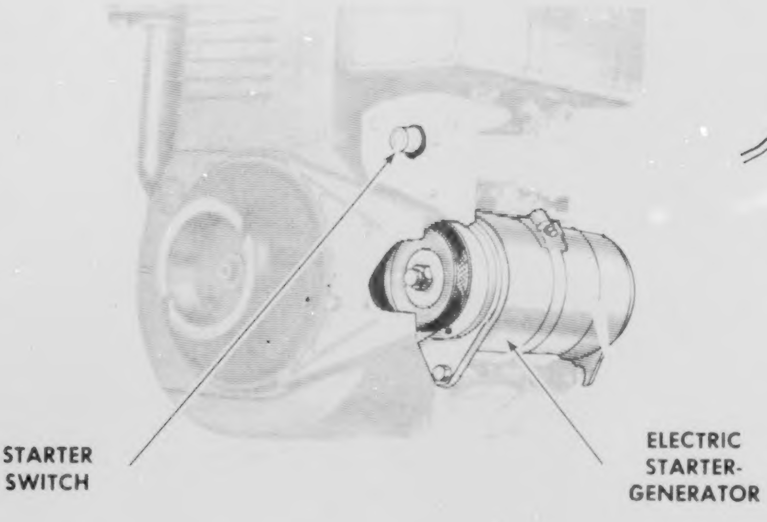
TYPES OF STARTERS
(Continued)

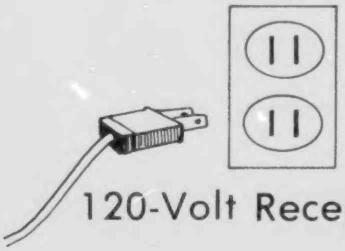

WINDUP STARTER BEING WOUND
CRANK HANDLE
HOUSING
RATCHET SPRING
RATCHET GEAR
STARTER CONTROL LEVER (LOCKED)
RECOIL SPRING (BEING WOUND)
HOLDING MECHANISM
STARTER DRIVE
FLYWHEEL CUP
ENGINE FLYWHEEL

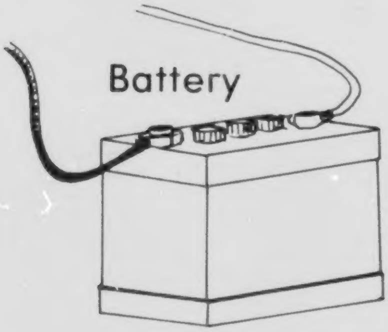

WINDUP STARTER OPERATING
CONTROL LEVER (DISENGAGED)
RATCHET (HOLDING)
SPRING (UNWINDING)
FLYWHEEL TURNING

WIND UP

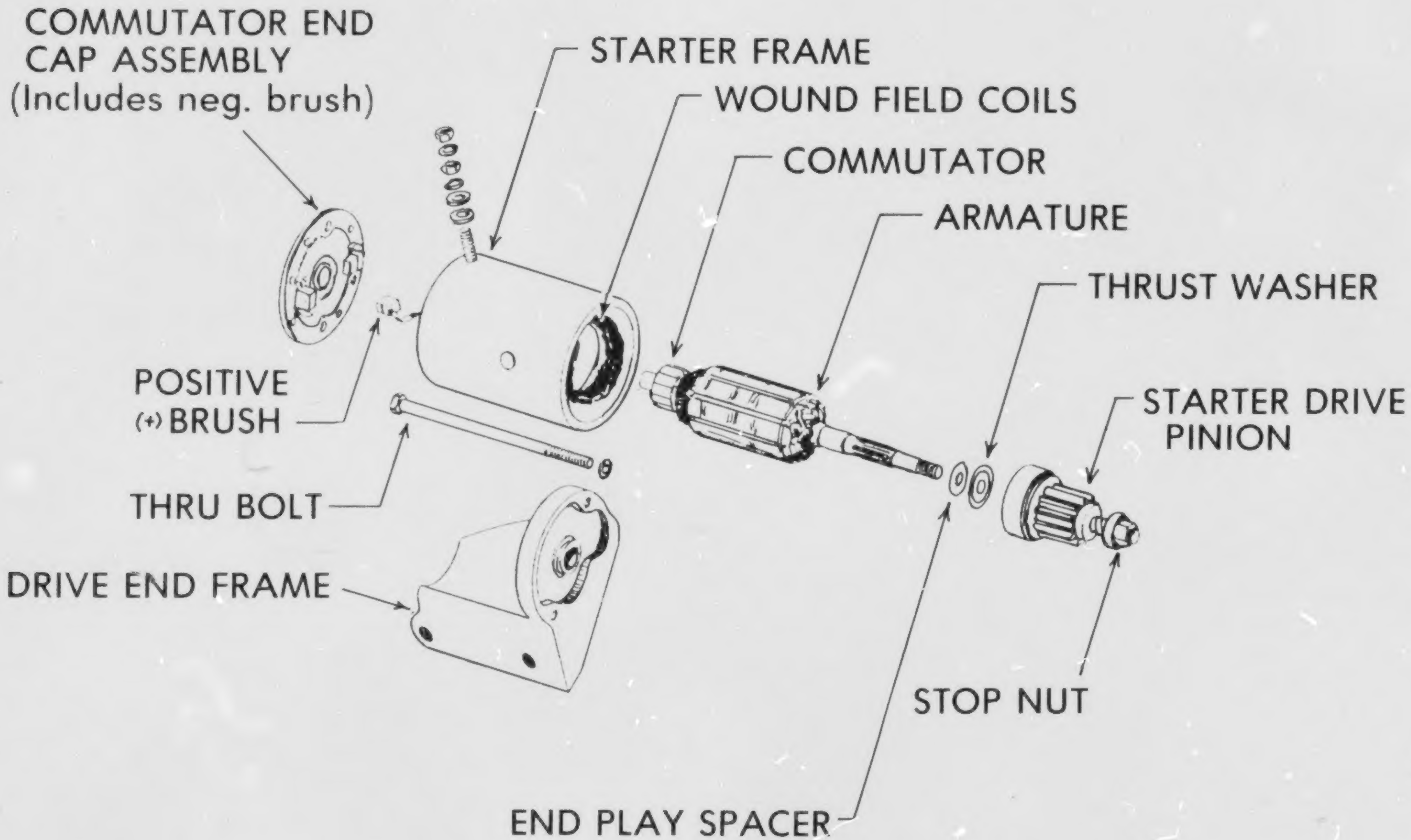
ELECTRIC


STARTER SWITCH
ELECTRIC STARTER-GENERATOR

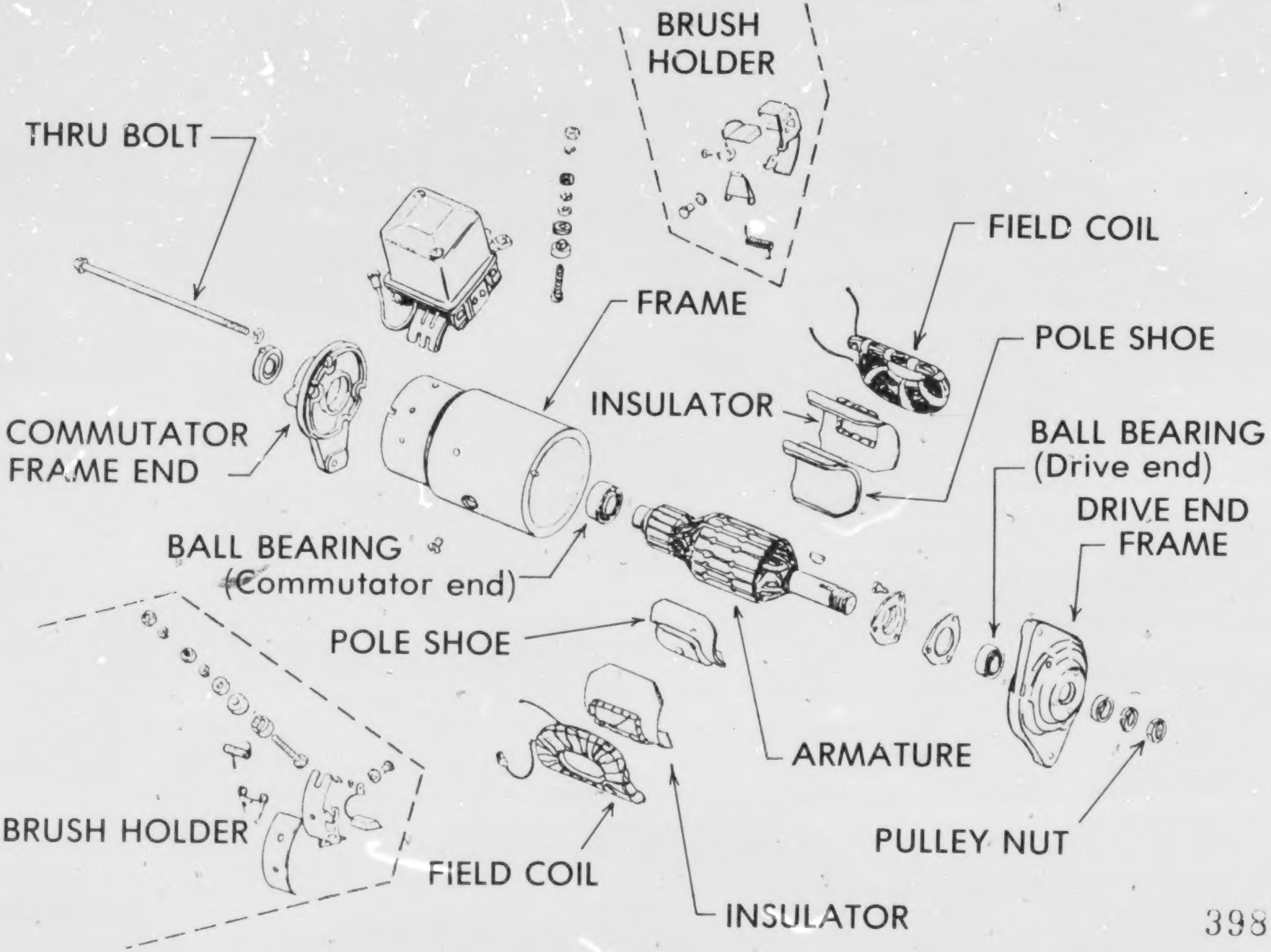

120-Volt Receptacle



PARTS OF A DC WOUND FIELD STARTER


COMMUTATOR END CAP ASSEMBLY (Includes neg. brush)
STARTER FRAME
WOUND FIELD COILS
COMMUTATOR
ARMATURE
THRUST WASHER
STARTER DRIVE PINION
POSITIVE (+) BRUSH
THRU BOLT
DRIVE END FRAME
STOP NUT
END PLAY SPACER

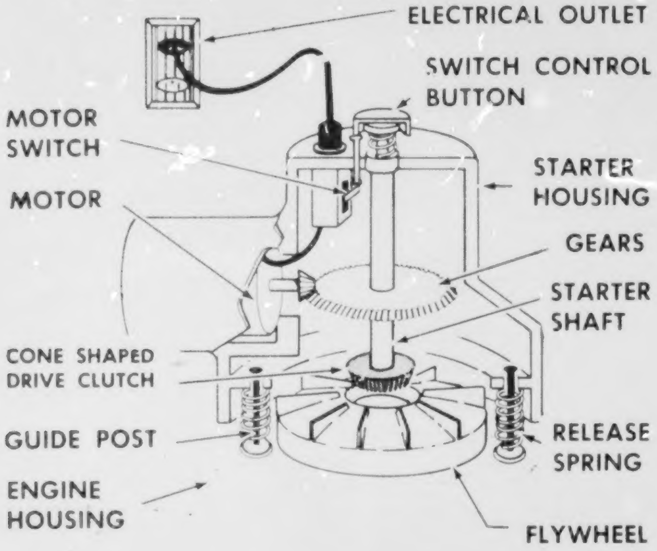
PARTS OF A DC STARTER GENERATOR


BRUSH HOLDER
THRU BOLT
FIELD COIL
FRAME
POLE SHOE
INSULATOR
BALL BEARING (Drive end)
COMMUTATOR FRAME END
DRIVE END FRAME
BALL BEARING (Commutator end)
POLE SHOE
ARMATURE
BRUSH HOLDER
PULLEY NUT
FIELD COIL
INSULATOR

TM 4

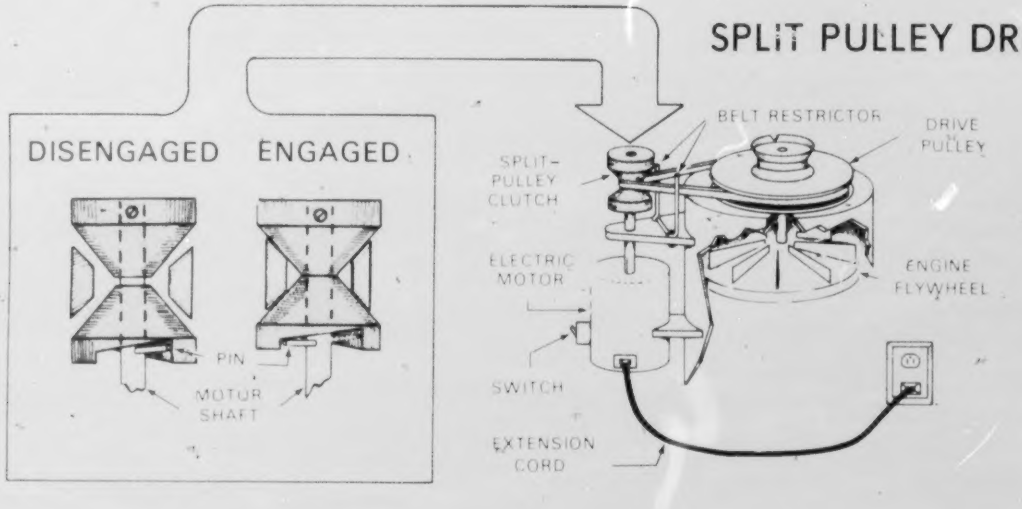
SE - 177-C

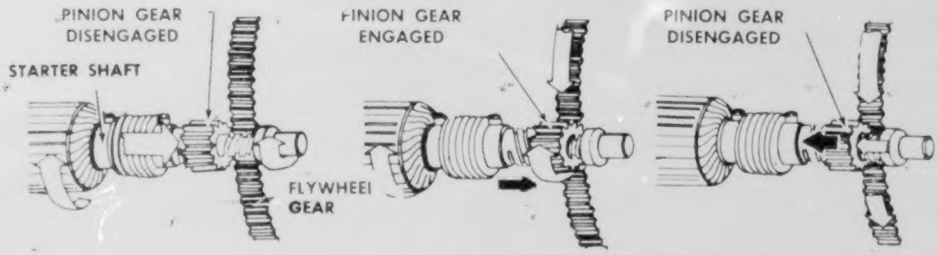
TYPES OF STARTER DRIVES


ELECTRICAL OUTLET
SWITCH CONTROL BUTTON
MOTOR SWITCH
STARTER HOUSING
MOTOR
GEARS
STARTER SHAFT
CONE SHAPED DRIVE CLUTCH
GUIDE POST
RELEASE SPRING
ENGINE HOUSING
FLYWHEEL

CONE DRIVE

SPLIT PULLEY DRIVE


DISENGAGED
ENGAGED
PIN
MOTOR SHAFT
BELT RESTRICTOR
DRIVE PULLEY
SPLIT-PULLEY CLUTCH
ELECTRIC MOTOR
ENGINE FLYWHEEL
SWITCH
EXTENSION CORD


PINION GEAR DISENGAGED
STARTER SHAFT
FLYWHEEL GEAR
PINION GEAR ENGAGED
PINION GEAR DISENGAGED

BENDIX DRIVE

STARTING SYSTEMS
UNIT IV

JOB SHEET #1-REMOVE, DISASSEMBLE, TEST, SERVICE, REASSEMBLE, AND REPLACE A DC STARTER

I. Tools and materials

- A. Hand tool assortment
- B. Armature grounder and test light
- C. Solvent and parts brush or rag
- D. Ignition wrench set
- E. Awl
- F. Safety glasses

II. Procedure

A. Remove starter

1. Disconnect battery ground cable
2. Remove cables and electrical wires from starter

   (CAUTION: Use two wrenches on terminals when removing top nut to prevent twisting terminal.)

   (NOTE: Carefully identify location of wires with masking tape.)
3. Remove starter mounting bolts as required
4. Remove starter brackets and shields as required
5. Remove starter from engine

B. Disassemble starter

1. Clean outside case with solvent and brush or rag

   (NOTE: Do not use excessive amounts or submerge starter in solvent. Solvent should not be allowed to enter the starter.)
2. Scribe mating surfaces for reassembly
3. Remove thru bolts
4. Remove end cap
5. Lift spring and release brush from end cap

JOB SHEET #1

6. Remove front plate with armature

   (NOTE: Some models may have starter mounting attached to front plate. See Figure 1.)

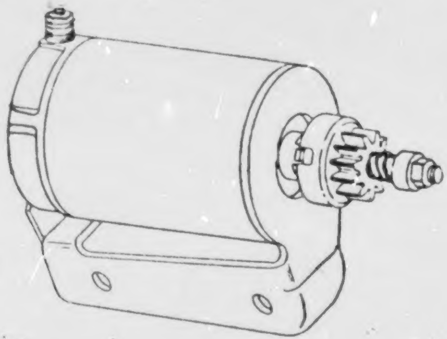


FIGURE 1

7. Place armature in vise

   (NOTE: Be sure to use wooden blocks or jaw protectors on the vise to keep from damaging armature.)

8. Disassemble drive assembly (Figure 2)

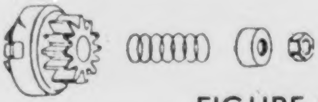


FIGURE 2

   a. Remove stop nut

   b. Separate spring, washers, and drive pinion

      (NOTE: Be sure to note location of thrust washers on armature shaft if used.)

C. Test and service

1. Clean all starter components

   (NOTE: Clean all parts by wiping with clean cloths. The armature, field coils, and starter drive assembly must not be washed in solvent.)

2. Arrange all starter components for inspection

3. Inspect starter bushings for looseness and replace as required

4. Inspect starter brushes for wear

   (NOTE: Brushes worn to half their original length or less should be replaced.)

JOB SHEET #1

5. Inspect the starter drive

   (NOTE: The starter drive pinion gear should turn freely in one direction and lock when turned slowly in the other direction.)

6. Inspect armature commutator

   (NOTE: If the armature commutator is rough or out-of-round it should be turned down using suitable equipment.)

7. Test the armature for short circuits (Figure 3)

   (NOTE: Place the armature on a growler and rotate the armature while holding a hacksaw blade over the armature core. If the blade vibrates, the armature is shorted and will require replacement.)

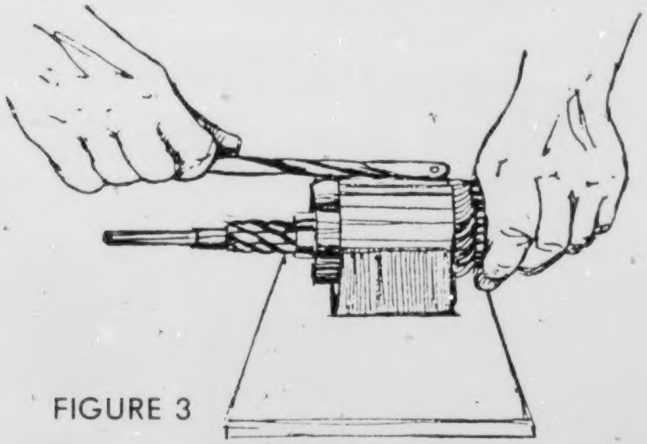


FIGURE 3

8. Check armature for ground (Figure 4)

   (NOTE: Place one lead of a test lamp on the armature core or shaft and the other on the commutator. If the lamp lights, the armature is grounded and will require replacement.)

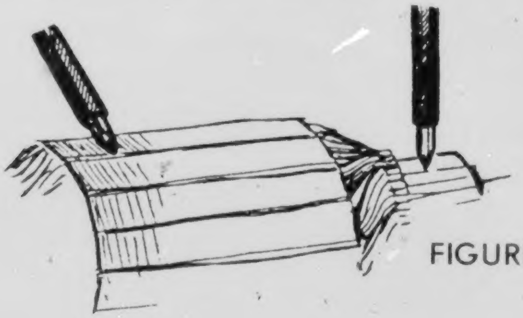


FIGURE 4

JOB SHEET #1

9. Check field coil for open circuit (Figure 5)

   (NOTE: Place one lead of the test lamp on the insulated brush and the other on the field connection tab. If the lamp does not light, the field coil is open and will require replacement.)

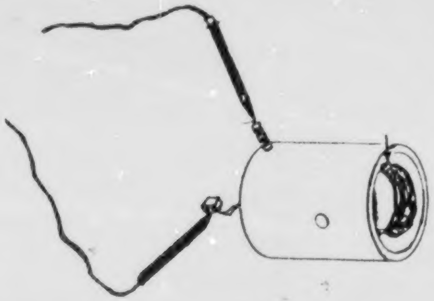


FIGURE 5

10. Replace worn or damaged parts

D. Reassemble starter

1. Place front plate back on armature

   (NOTE: Be sure and replace thrust washers if used.)

2. Replace drive assembly

   (NOTE: Torque stop nut to manufacturer's specifications.)

3. Lift spring and reinstall brush in end cap

4. Place end cap on starter

5. Line up scribe marks

6. Install thru bolts

   (NOTE: Torque to manufacturer's specifications.)

E. Replace starter

1. Clean starter mounting surfaces

2. Position starter in mounting position and start bolts

3. Tighten mounting bolts securely

4. Place all wire and cables on correct terminals

5. Tighten nuts securely

   (NOTE: Double wrench as in removal, hold terminals securely, and do not overtighten top nuts.)

JOB SHEET #1

6. Replace all brackets and shields
7. Tighten all bolts and nuts securely
8. Replace battery ground cable
9. Start engine several times to check starter

STARTING SYSTEMS
UNIT IV

JOB SHEET #2-REPLACE STARTER REWIND SPRING

I. Tools and materials

   A. Hand tool assortment

   B. Rope inserter

   C. 3/4" square piece of square stock

   D. New recoil spring

   E. New starter rope

   F. Small amount of grease

   G. Cleaning solvent

   H. Safety glasses

II. Procedure

   A. Remove shroud from engine

   B. Cut knot at starter pulley to remove rope

   (NOTE: Apply pressure to the pulley so the spring will unwind slowly. Use a cloth or a gloved hand.)

   C. Grasp outer end of starter spring with pliers and pull spring out of housing as far as possible (Figure 1)

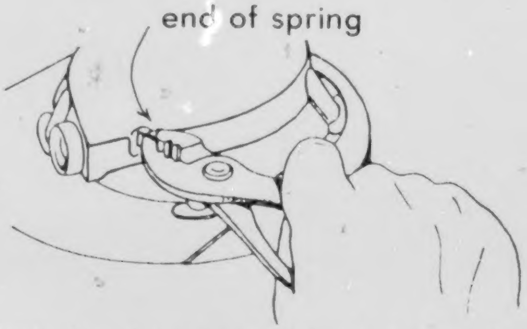


FIGURE 1

   D. Bend one of the bumper tangs up and lift out starter pulley, disconnecting spring

   (CAUTION: Do not allow spring to fly out of housing as injury could result.)

   E. Clean starter spring in solvent and wipe dry

JOB SHEET #2

F. Straighten spring and install spring into blower housing slot and hook into pulley (Figure 2)

(NOTE: Replace spring if it is damaged.)

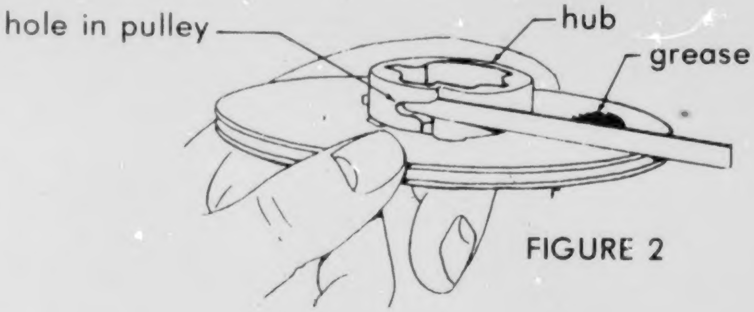


FIGURE 2

G. Replace nylon bumpers if worn (Figure 3)

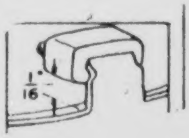


FIGURE 3

H. Set pulley into housing and bend bumper tang down

I. Place 3/4" square stock into center of pulley hub and wind pulley until spring is tight

J. Back off one turn until hole in pulley for rope, knot and eyelet in blower housing are in alignment

(NOTE: Be sure spring is locked securely in smaller portion of tapered hole.)

K. Replace starter rope with a new rope if it is frayed

(NOTE: Burn each end of new rope with a match and wipe with a rag to prevent swelling and unraveling)

(CAUTION: Use the correct diameter and length of rope.)

JOB SHEET #2

L. Secure wrench holding spring tension (Figure 4)

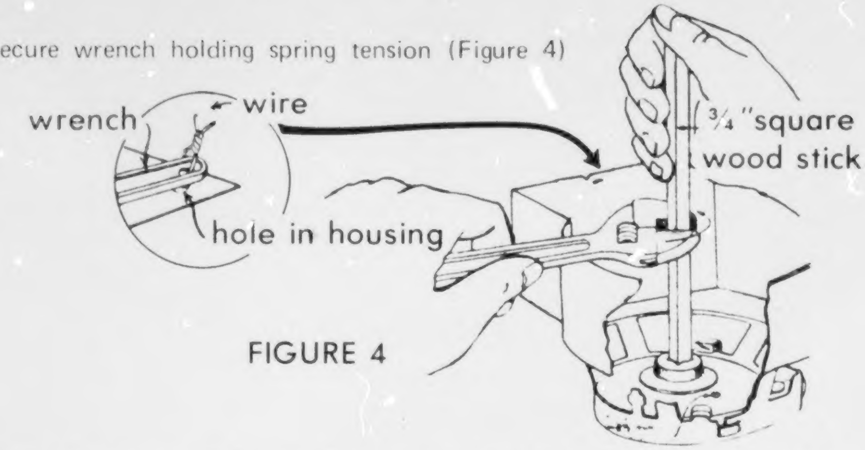

wrench
wire
¾"square
wood stick
hole in housing

FIGURE 4

M. Thread rope through rope eyelet in housing and out pulley hole (Figure 5)

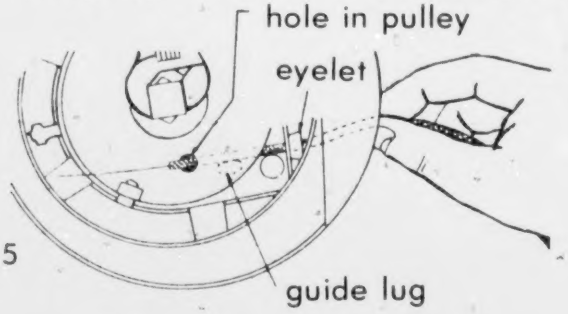

hole in pulley
eyelet
guide lug

FIGURE 5

N. Tie a knot in the rope and pull it tight

O. Inspect and clean starter clutch assembly as needed (Figure 6)

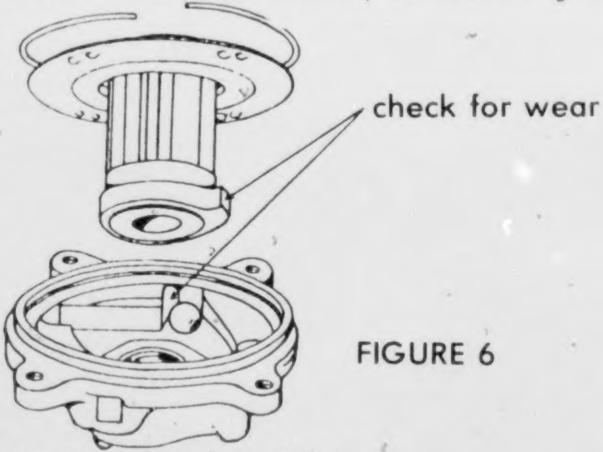

check for wear

FIGURE 6

P. Reinstall starter and shroud on engine

Q. Start engine several times to be sure recoil spring and clutch operate correctly

STARTING SYSTEMS
UNIT IV

NAME ____________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Device which converts mechanical or electrical power into rotating motion for cranking engine

_____b. Housing which connects and contains starter component parts

_____c. Main shaft in starter, composed of commutator segments, windings, and bushing or bearing journal

_____d. Sliding contacts which transfer electrical energy to commutator

_____e. Gear that meshes with flywheel to crank engine

_____f. Ends of magnets in the field frame of a starting motor

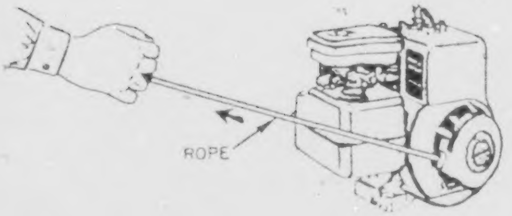
_____g. Wire wrapped around pole pieces to increase the strength of the magnetic field when current is applied

_____h. Safety device which allows engine to be started in neutral only

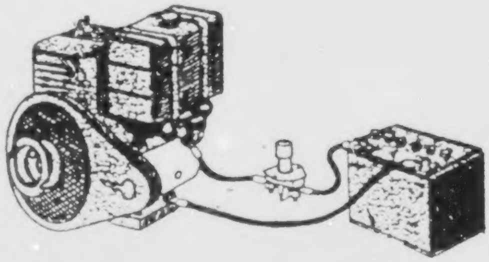
_____i. Electromagnetic device which provides a reciprocating motion for remote control of starting circuit

1. Solenoid
2. Brushes
3. Pole shoes
4. Starter frame
5. Safe interlock (neutral interlock)
6. Starter
7. Armature
8. Field coils
9. Starter drive pinion

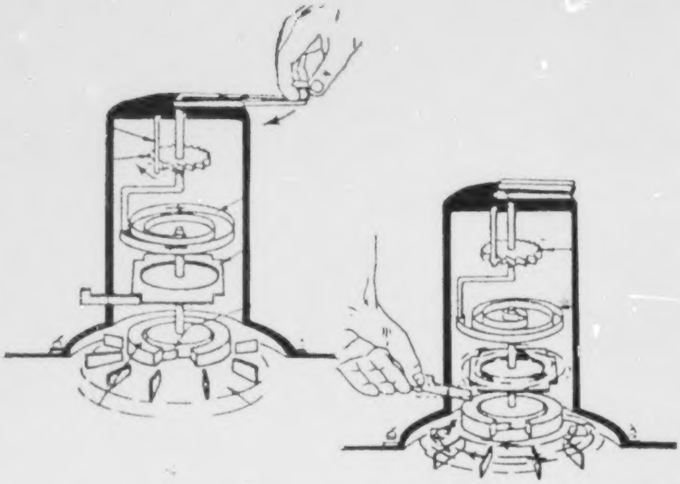
2. Identify the types of small gas engine starters.



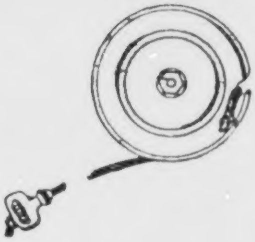
a. ____________________



b. ____________________



c. ______________________



d. ______________________

3. Match the components of the mechanical starting system on the right to the correct functions.

______a. Returns pawl to neutral position during rewind cycle

______b. Locks pulley to crankshaft adapter on starting pull of rope

______c. Housing for pawls that lock to crankshaft adapter

______d. Used to automatically rewind the starter rope after each starting attempt

______e. Cover for the starter mechanism

1. Starter housing
2. Recoil spring
3. Pawl spring
4. Engaging pawl
5. Pulley

4. Match the components of the DC starting system on the right to the correct functions.

______a. Source of electrical power

______b. Device which activates the starter motor switch

______c. Switch which closes the high amperage circuit from battery to starter

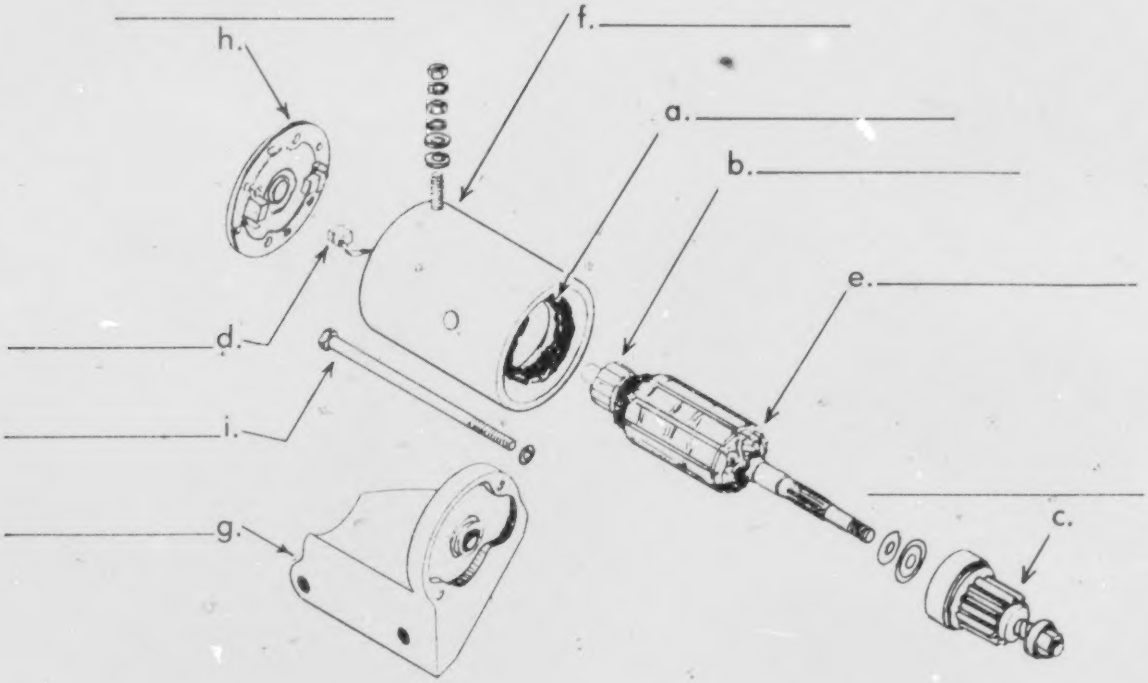
______d. Drives the flywheel to crank the engine

1. Starter motor
2. Key switch
3. Battery cables
4. Battery
5. Switch wire
6. Starter motor switch

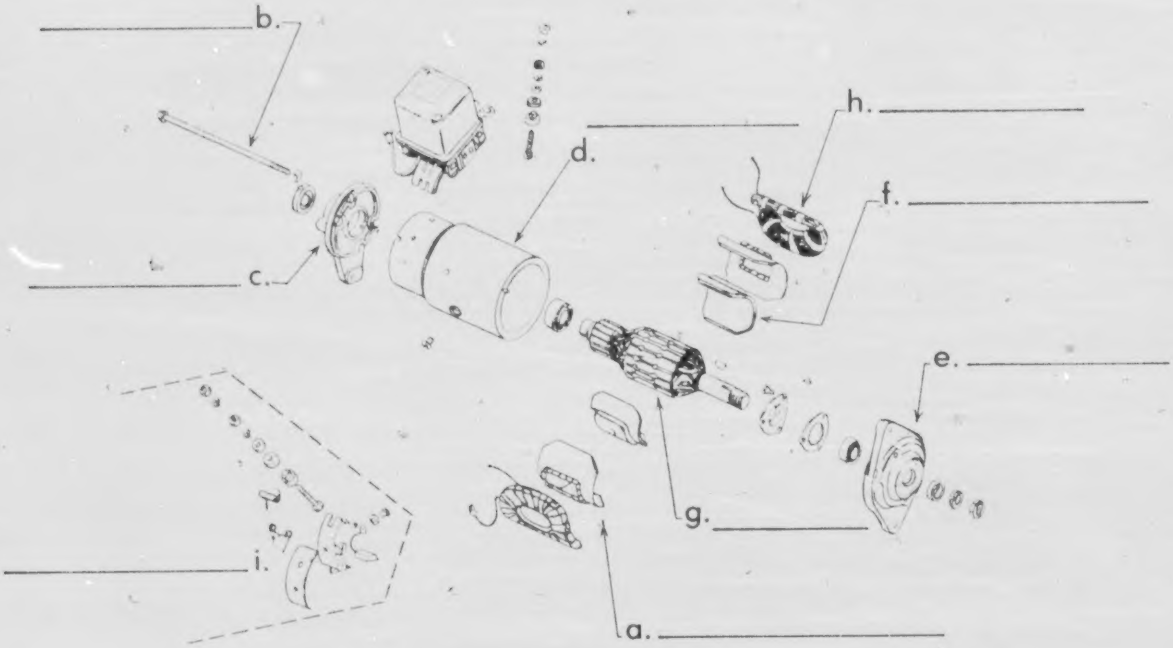
_____ e. Conductor that carries a low amount of current to energize the starter motor switch

_____ f. Conductors which carry large amounts of current to complete the starter circuit

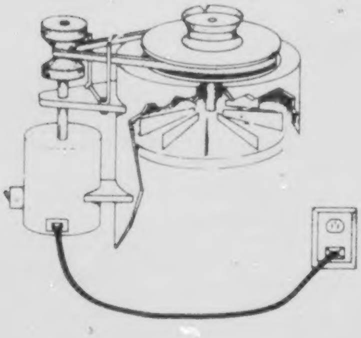
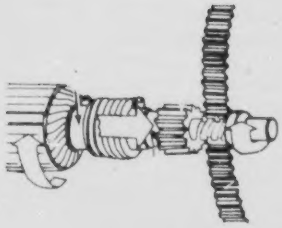
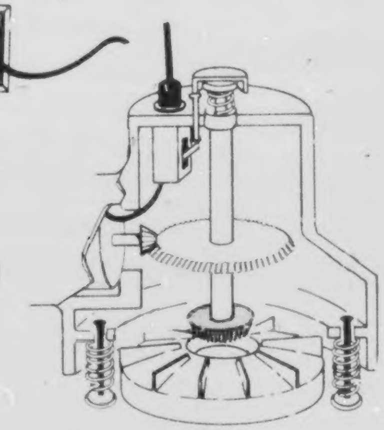
5. Identify the main parts of a DC wound field starter.



6. Identify the main parts of a DC starter generator.



7. Identify the types of starter drives.

a. ____________ b. ____________ c. ____________

8. Demonstrate the ability to:

   a. Remove, disassemble, test, service, reassemble, and replace a starter.

   b. Replace starter rewind spring.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

STARTING SYSTEMS
UNIT IV

ANSWERS TO TEST

1. a. 6
   b. 4
   c. 7
   d. 2
   e. 9
   f. 3
   g. 8
   h. 5
   i. 1
2. a. Rope-rewind
   b. Electric (AC and DC)
   c. Wind up
   d. Rope-wind
3. a. 3
   b. 4
   c. 5
   d. 2
   e. 1
4. a. 4
   b. 2
   c. 6
   d. 1
   e. 5
   f. 3
5. a. Wound field coils
   b. Commutator
   c. Starter drive pinion
   d. Positive brush
   e. Armature

f. Starter frame

g. Drive end frame

h. Commutator end cap assembly

i. Thru bolt

6. a. Insulator

b. Thru bolt

c. Commutator frame end

d. Frame

e. Drive end frame

f. Pole shoe

g. Armature

h. Field coil

i. Brush holder

7. a. Split pulley drive

b. Bendix drive

c. Cone drive

8. Performance skills evaluated to the satisfaction of the instructor

LUBRICATION SYSTEMS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list functions of engine oils and match oil additives to their functions. The student should also be able to name oil contaminants and discuss ways to avoid oil contamination. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with lubrication systems to the correct definitions.
2. List five purposes of the lubrication system.
3. List the two main types of lubrication systems.
4. List four purposes of the crankcase breather.
5. Match the components of the crankcase breather to the correct purposes.
6. List five functions of engine oil.
7. Select the characteristics of a good engine oil.
8. Discuss oil ratings and classifications.
9. Explain the SAE viscosity number.
10. Explain the API classification system.
11. Name six oil contaminants.
12. Match oil additives to their functions.
13. Select factual statements about oil.
14. List general rules for selection and use of oils for best engine performance.
15. Discuss two cycle oil selection and use.

16. List ways to avoid oil contamination.
17. Demonstrate the ability to:
    a. Change engine oil and filter.
    b. Service crankcase breather.

LUBRICATION SYSTEMS
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information sheet.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Invite speakers from industry to talk on lubricants.

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters:

    1. TM 1--Dipper Lubrication System

    2. TM 2--Slinger Lubrication System

    3. TM 3--Dipper and Pump Lubrication System

    4. TM 4--Dipper, Pump, and Constant-Level Sump

    5. TM 5--Two Types of Crankcase Breathers

    6. TM 6--Crankcase Breather Vented to Carburetor

7. TM 7--Crankcase Breather Principles (4 Cycle Engine)
8. TM 8--A Typical Crankcase Breather
9. TM 9--Comparison of Crankcase Oils (Viscosity-Grades)
10. TM 10--SAE Viscosity
11. TM 11--SAE Viscosity (Continued)

D. Test

E. Answers to test

II. References:

A. *Fundamentals of Service: Fuels, Lubricants, and Coolants.* Moline, Illinois: Deere and Company, 1970.

B. *Fuels and Lubricants.* Athens, Georgia: American Association for Vocational Instructional Materials, 1973.

LUBRICATION SYSTEMS
UNIT I

INFORMATION SHEET

I. Terms and definitions

  A. Additives-Certain chemicals added to oil to provide extra performance

  B. Multi-grade oil--Oils compounded to behave as light oils at cold temperatures and heavy oils at warm temperatures

  C. SAE-Society of Automotive Engineers

  D. API--American Petroleum Institute

  E. MIL--Oil specifications prepared by the Ordnance Department of the Military Forces

  F. ASTM--American Society for Testing Materials

  G. Viscosity-A measure of the fluidity of an oil at a given temperature

  H. Viscometer--Instrument used to measure the length of time in seconds required for a specified volume of oil to flow through a small orifice when the oil is brought to a specified temperature

  I. Friction--Resistance to movement between two objects placed in contact with one another

  J. "W" oils--Types of oils that are suitable for winter service

  (NOTE: Type "W" viscosities are determined at 0°F or -18°C.)

  K. Sludge--Heavy, thick residue found in the bottom of an oil pan caused by oil deterioration or oil contamination

  L. Blow-by--Gases under pressure leaking by the piston rings during combustion and the power stroke

  M. Dipper--Device fastened to connecting rod as a means of splashing oil

  N. Slinger--Device rotated by the camshafts for splashing oil

  O. Oil gally (passage)--Passageways in the engine used to carry oil from one area to another

  P. Pressure relief valve--Valve in the lubrication system designed to limit maximum oil pressure

INFORMATION SHEET

Q. Oil pickup--Device allowing the oil pump to pick up oil which is free from sediment in the oil pan

R. Oil pan (sump)--Cover on the bottom of the engine block providing a reservoir for the engine oil

S. Oil filter--Device used to remove abrasive particles from the oil

II. Purposes of lubrication system

A. Reduces friction

B. Cools engine parts

C. Absorbs shock and reduces engine noise

D. Forms seal between piston rings and cylinder walls

E. Acts as a cleansing agent

III. Types of lubrication systems (Transparencies 1, 2, 3, and 4)

(NOTE: Some engines use both systems.)

A. Splash system

1. Dipper type

2. Slinger types

B. Pump system

1. Barrel and plunger type

2. Gear and rotor type

IV. Purposes of crankcase breather (Transparencies 5, 6, and 7)

A. Allows blow-by to escape

B. Limits corrosion of engine parts

C. Prevents oil leaks at seals and gaskets by relieving crankcase pressure

D. Allows entrance of fresh air

V. Components of the crankcase breather and their purposes (Transparency 8)

A. Cover (valve)--Prevents entrance of excessive amounts of dirt

B. Filter--Prevents dirt and abrasives from entering air

INFORMATION SHEET

C. Baffle--Keeps excessive oil from splashing onto filter

D. Reed--Limits amount of fresh air entering crankcase and allows blow-by to leave engine

VI. Functions of engine oil

A. Reduces friction and wear

B. Cools moving parts

C. Helps seal cylinders

D. Keeps parts clean

E. Cushions moving parts

VII. Characteristics of good engine oil

A. Keeps a protective film on moving parts

B. Resists breakdown at high temperatures

C. Resists corrosion and rusting

D. Prevents carbon build-up

E. Prevents sludge formation

F. Flows easily at low termperatures

G. Resists foaming

H. Resists breakdown after long use

VIII. Oil ratings and classification

A. SAE--Viscosity established by Society of Automotive Engineers

B. API--Service classification established by American Petroleum Institute

C. MIL--Specifications prepared by Ordnance Department of the U.S. Army, Navy, and Air Force

D. ASTM--Engine sequence tests whose procedures are adopted by the American Society for Testing Materials

IX. SAE viscosity number (Transparencies 9, 10, and 11)

A. Oils vary in viscosity as temperatures change

(NOTE: Oil becomes more fluid as temperatures increase and less fluid as temperatures decrease.)

INFORMATION SHEET

B. Lighter oils for winter use are specified at 0°F and carry a 5w, 10w or 20w symbol

(NOTE: Specifications are determined by time of flow through an instrument, such as a Saybolt viscometer, in seconds.)

C. Heavier oils are specified at 210°F and carry a 20, 30, 40, or 50 viscosity number

(NOTE: Compounded oils called multi-grade behave as light oils in cold temperatures and heavier oils at high temperatures, for example 10w-40 can replace four single grade oils.)

X. API classification system

A. Joint effort of API, ASTM, and SAE organizations

B. Attempts to clarify oil specifications and oil qualities between the engine manufacturer, the petroleum industry, and the customer

XI. Oil contaminants

A. Foreign particles

B. Water

C. Antifreeze

D. Fuel

E. Oxidation

F. Acids

XII. Oil additives and their functions

(NOTE: Most oils already have these additives.)

A. Anti-corrosion--Helps prevent failure of alloy bearings from corrosive acids caused by combustion

B. Oxidation inhibitor--Prevents acid, varnish, and sludge formations

(NOTE: Oxidation causes oil to thicken.)

C. Anti-rust--Prevents rusting of metal parts during storage or downtime

D. Viscosity index improver--Helps oil give top lubricating protection at both high and low temperatures

INFORMATION SHEET

E. Pour point depressant--Prevents wax crystals from congealing in cold weather and forming clumps

F. Extreme pressure--Assures lubrication where extreme pressures between close tolerances are encountered

G. Detergent dispersant--Helps keep metal surfaces clean and prevents deposit formation

H. Foam inhibitor--Helps prevent air bubbles which would restrict lubrication

(NOTE: Fast circulation causes oil to foam.)

XIII. Factual statements about oil

A. Oil becomes unfit for further use as it absorbs contaminants and as additives are depleted

B. Multi-viscosity oils are not always preferred

C. Black oil does not mean time for an oil change

D. Buy quality oil filters as recommended by machine operator's manual

E. Oil oxidation results in thicker oil

F. Using a light oil until consumption increases, and then switching to a heavier oil, is not a good practice

G. Following operator's manual recommendations is critical to insure good performance

XIV. Selection and use of oils for best engine performance

A. Use brands which meet engine manufacturer's specifications

B. Drain and change at recommended intervals

C. Select oils which have been performance tested

D. Never mix oils of various MIL or API specifications

E. Bring engine up to normal operating temperature each time it is used

F. Keep oil containers covered, sealed, and protected to prevent contamination

INFORMATION SHEET

XV. Two cycle oil selection and use

A. Selection

1. Select only manufacturer's recommended SAE rating

(NOTE: Pumps on oil injection systems are designed for the weight oil recommended by the manufacturer. Using wrong SAE rating can affect lubrication.)

2. Select only oil recommended for use in either air cooled or water cooled two cycle engines

(NOTE: The use of standard detergent oils can cause carbon build up in cylinder head and around moving parts.)

B. Use

1. Use oil-fuel mixture recommended by manufacturer

(NOTE: Just because an oil is rated for a 50-1 mixture doesn't mean your engine is.)

2. Use oils that meet or exceed manufacturer's recommendations

(NOTE: A good quality oil may seem expensive when compared to a more economical brand, but it is inexpensive when compared to an overhaul.)

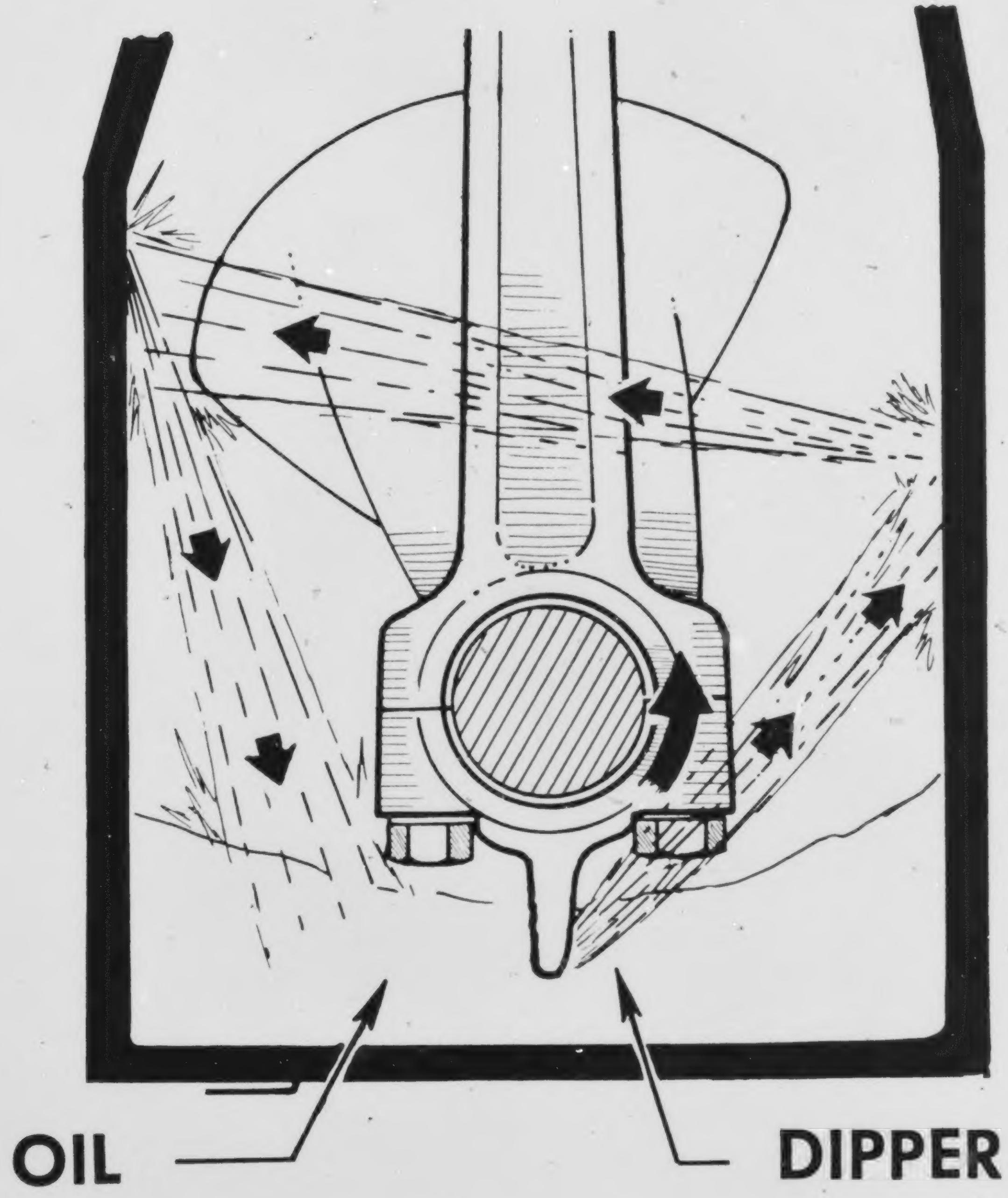
XVI. Ways to avoid oil contamination

A. Drain oil at recommended intervals

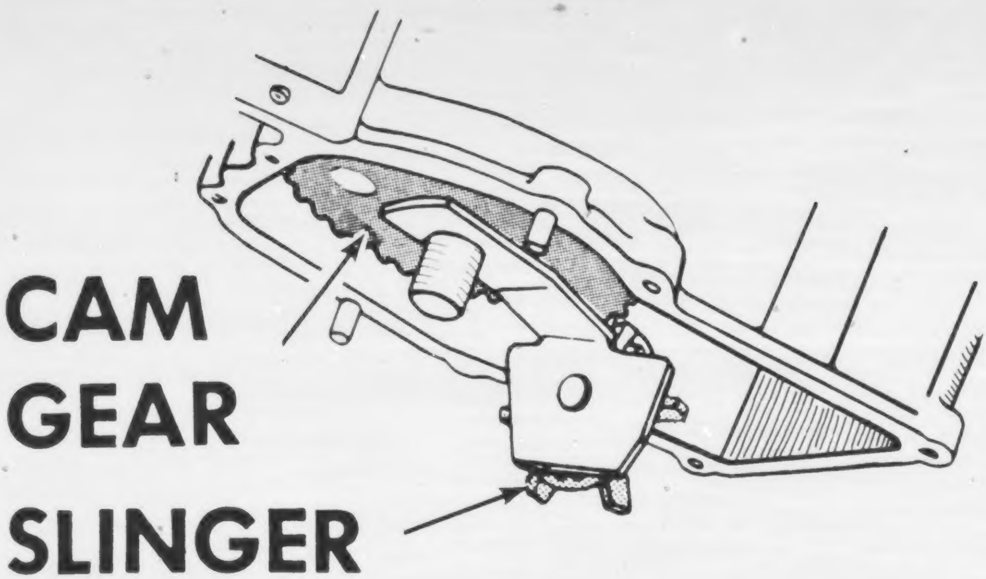
B. Use clean oil containers and work habits

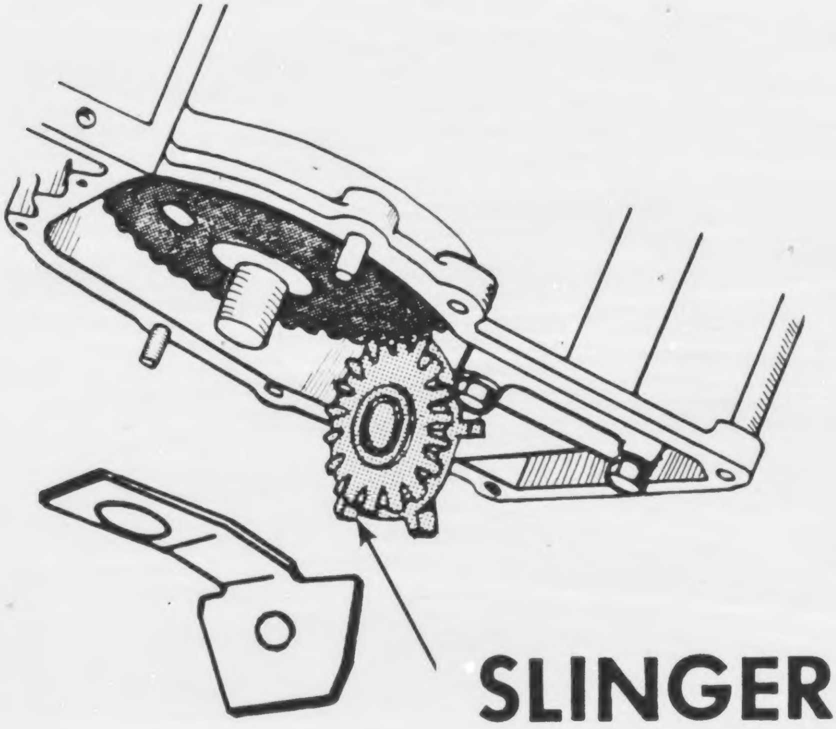
C. Replace or clean filters before they become plugged

DIPPER LUBRICATION SYSTEM

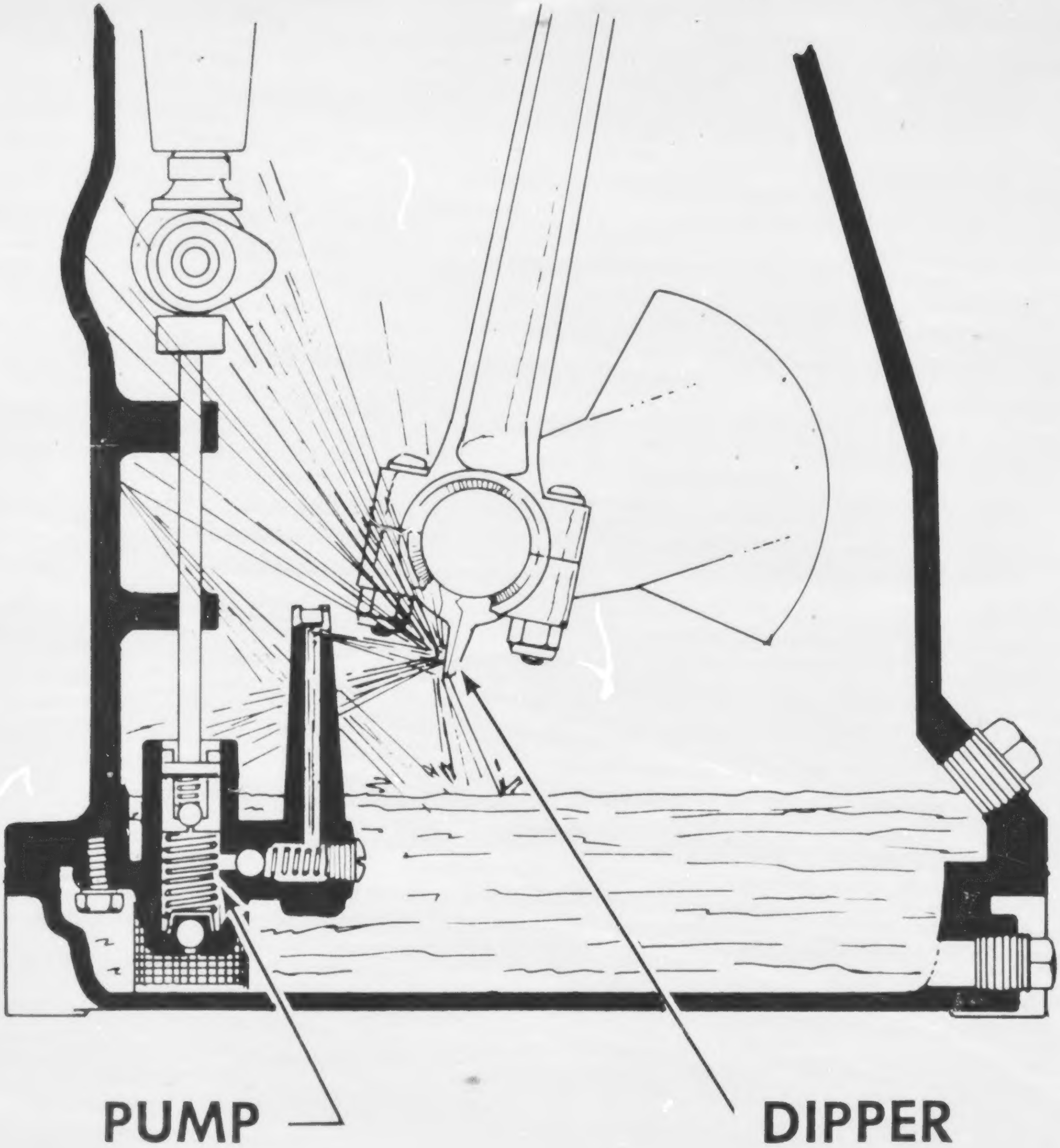


SLINGER LUBRICATION SYSTEM

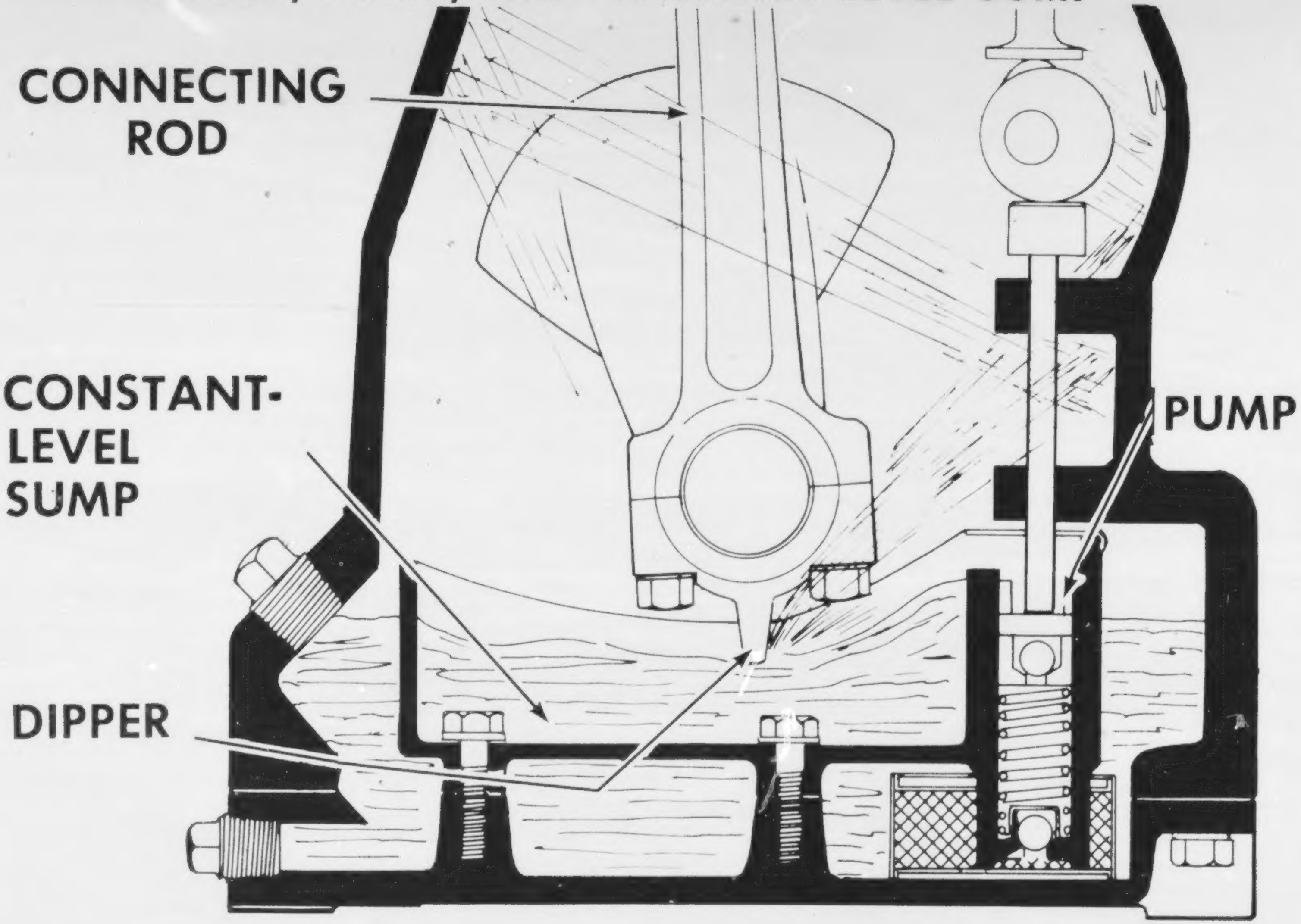

CAM
GEAR
SLINGER



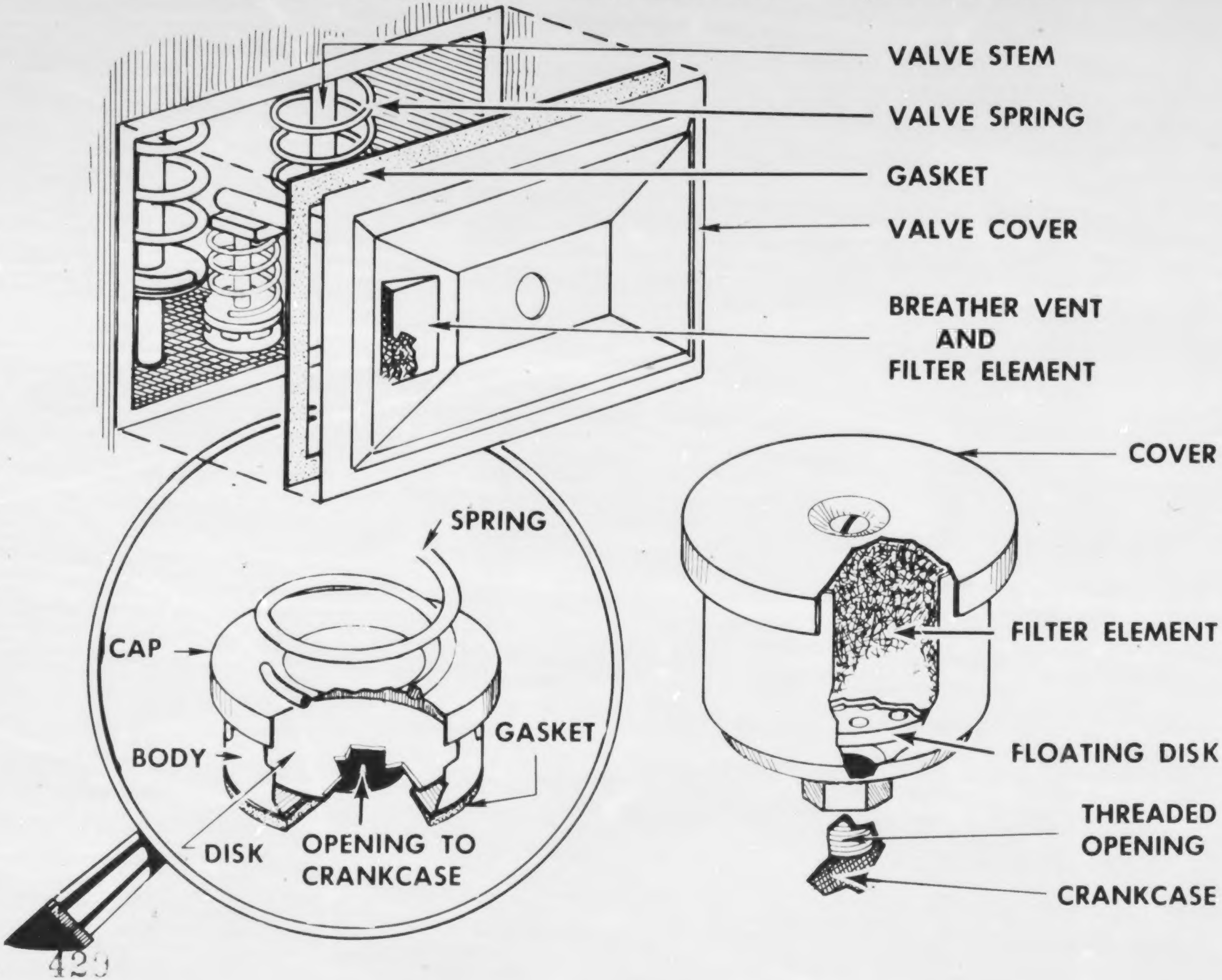
DIPPER AND PUMP LUBRICATION SYSTEM


PUMP
DIPPER

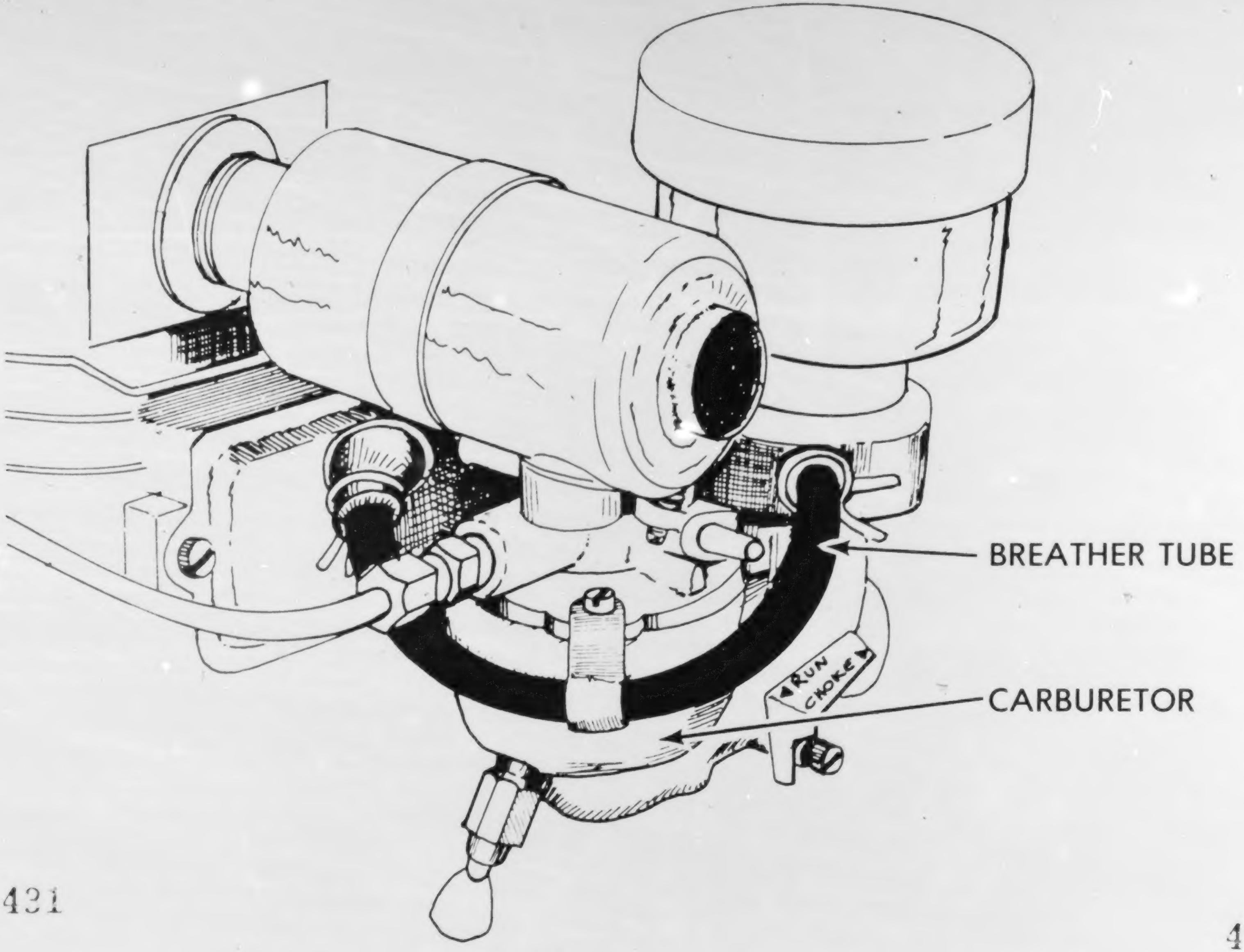
DIPPER, PUMP, AND CONSTANT-LEVEL SUMP


CONNECTING ROD
CONSTANT-LEVEL SUMP
DIPPER
PUMP

TWO TYPES OF CRANKCASE BREATHERS

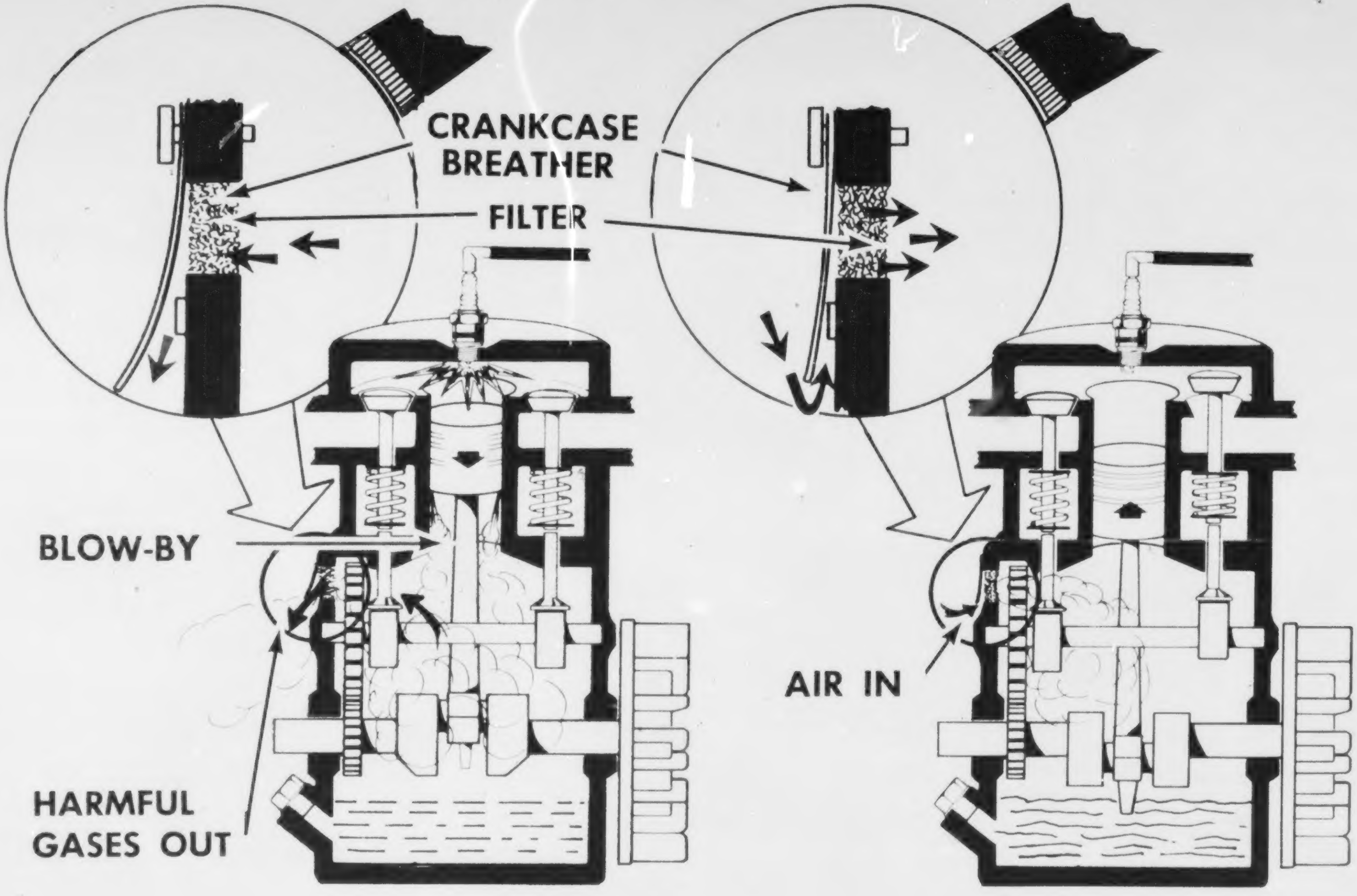

VALVE STEM
VALVE SPRING
GASKET
VALVE COVER
BREATHER VENT AND FILTER ELEMENT
SPRING
CAP
BODY
GASKET
DISK
OPENING TO CRANKCASE
COVER
FILTER ELEMENT
FLOATING DISK
THREADED OPENING
CRANKCASE

CRANKCASE BREATHER VENTED TO CARBURETOR


BREATHER TUBE
CARBURETOR
RUN
CHOKE

CRANKCASE BREATHER PRINCIPLES

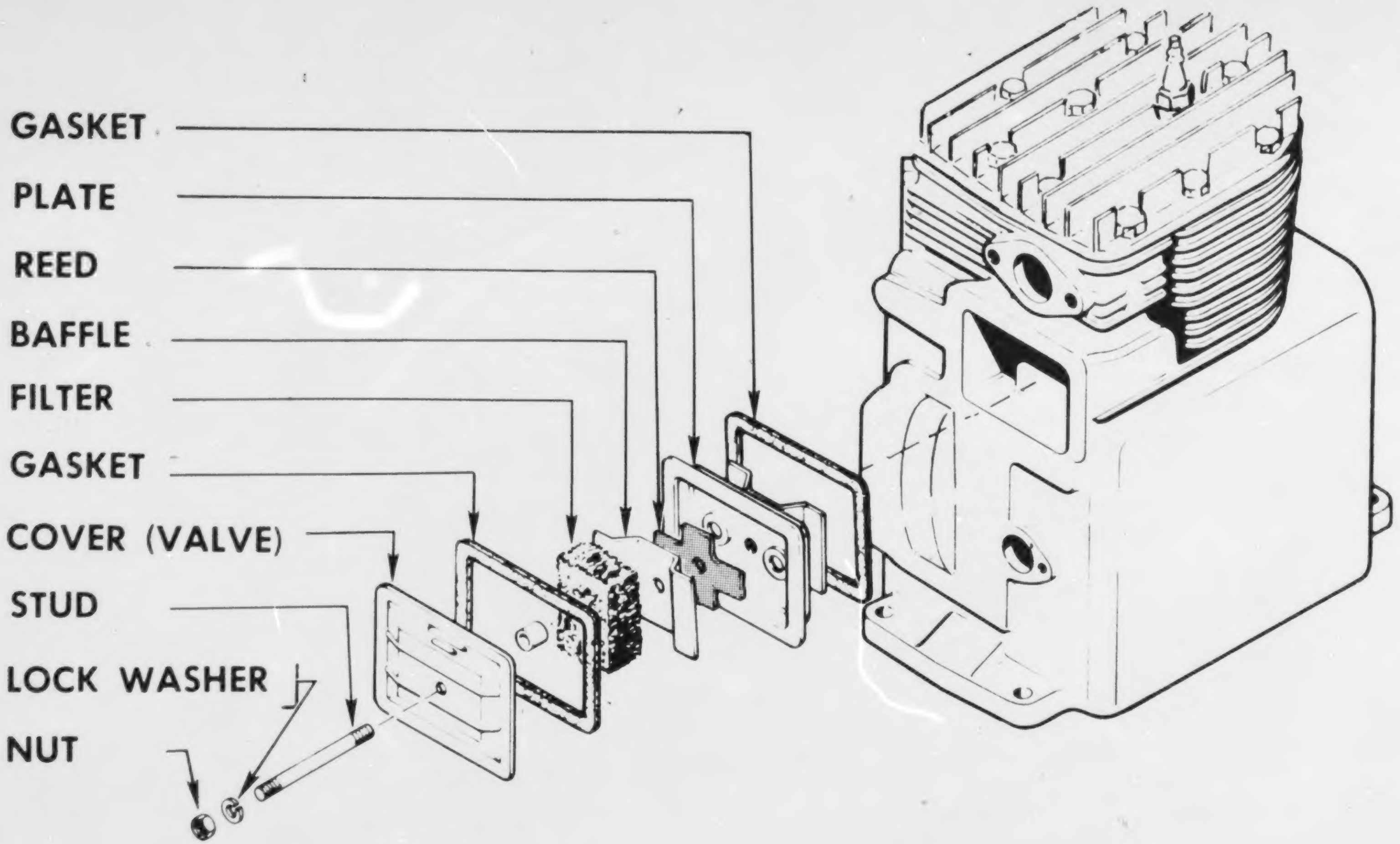
(4 CYCLE ENGINE)


CRANKCASE
BREATHER
FILTER
BLOW-BY
HARMFUL
GASES OUT
AIR IN

TM 7

SE - 23-D

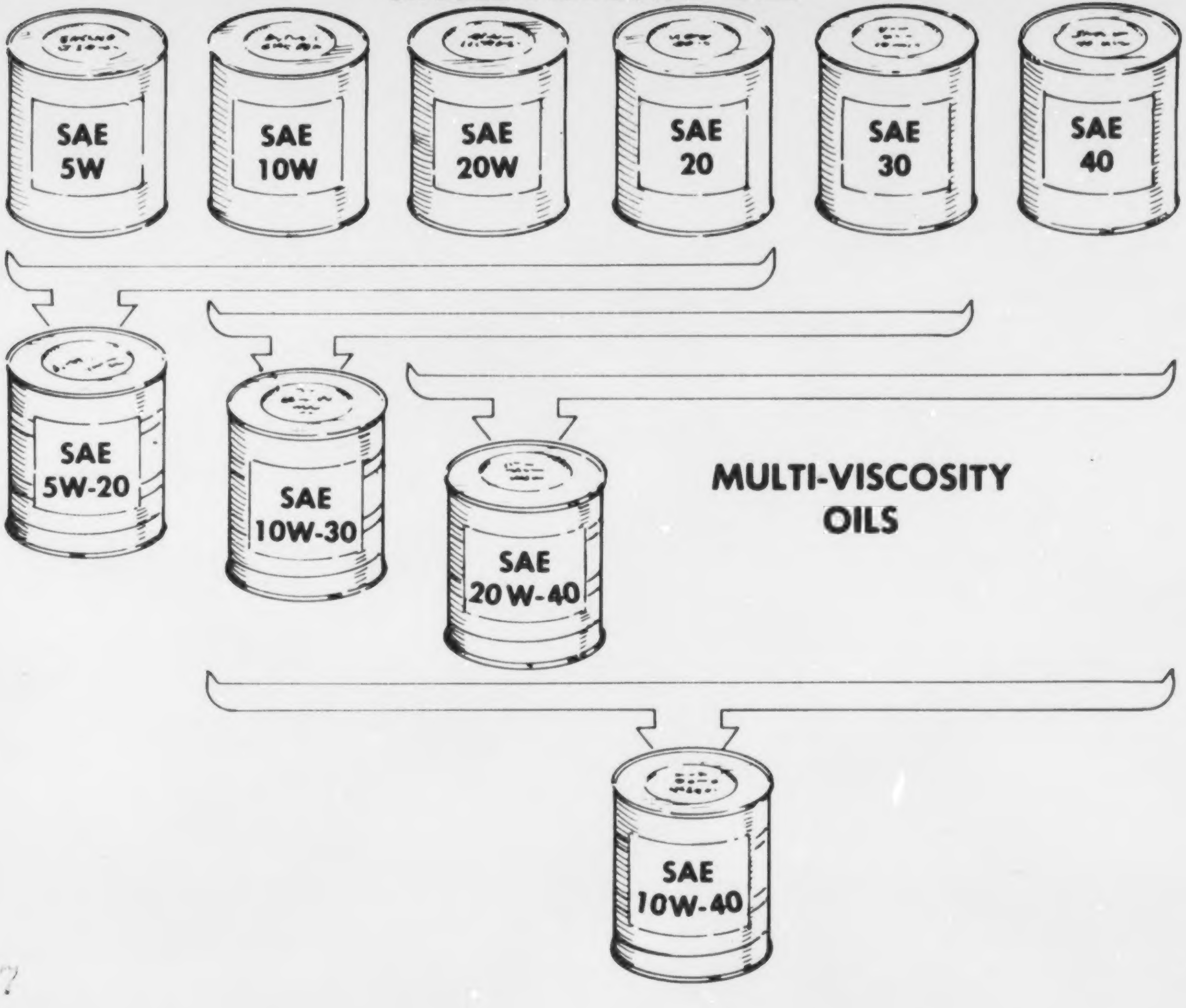
A TYPICAL CRANKCASE BREATHER


GASKET
PLATE
REED
BAFFLE
FILTER
GASKET
COVER (VALVE)
STUD
LOCK WASHER
NUT

COMPARISON OF CRANKCASE OILS

(VISCOSITY-GRADES)

SINGLE-VISCOSITY OILS


SAE 5W
SAE 10W
SAE 20W
SAE 20
SAE 30
SAE 40
SAE 5W-20
SAE 10W-30
SAE 20W-40
SAE 10W-40

MULTI-VISCOSITY OILS

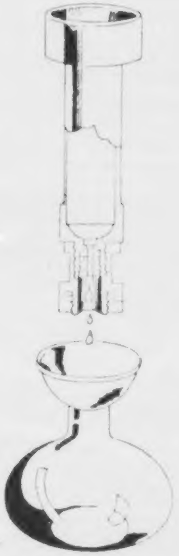
SAE Viscosity

SAE CRANKCASE OIL CLASSIFICATION				
SAE Viscosity Number	Time of Flow Through Saybolt Viscometer in Seconds			
	0°F.		at 210°F.	
	Min	Max	Min	Max
5W	—	6,000	—	—
10W	6,000 (Note A)	less than 12,000	—	—
20W	12,000 (Note B)	48,000	—	—
20	—	—	45	less than 58
30	—	—	58	less than 70
40	—	—	70	less than 85
50	—	—	85	110

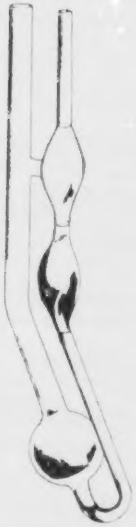
NOTE A: MINIMUM VISCOSITY AT 0°F. MAY BE WAIVED PROVIDED VISCOSITY AT 210°F. IS NOT BELOW 40 SECONDS, SAYBOLT UNIVERSAL.

NOTE B: MINIMUM VISCOSITY AT 0°F. MAY BE WAIVED PROVIDED VISCOSITY AT 210°F. IS BELOW 45 SECONDS, SAYBOLT UNIVERSAL

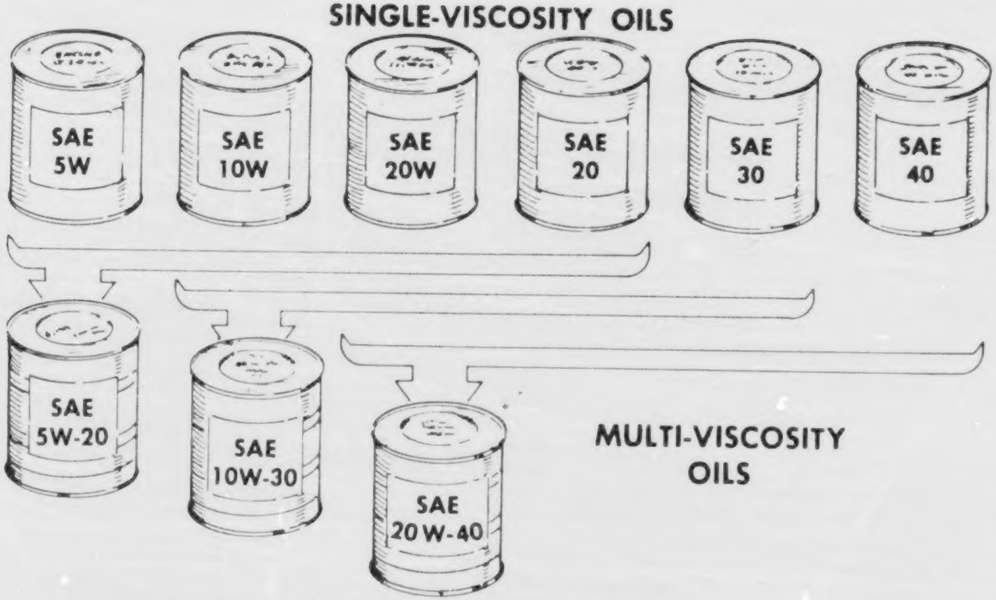
SAE Viscosity
(Continued)



SAYBOLT
VISCOMETER



KINEMATIC
VISCOMETER


SINGLE-VISCOSITY OILS
SAE 5W
SAE 10W
SAE 20W
SAE 20
SAE 30
SAE 40
SAE 5W-20
SAE 10W-30
SAE 20W-40
MULTI-VISCOSITY OILS

A MULTI-VISCOSITY OIL CAN REPLACE SEVERAL SINGLE-VISCOSITY OILS (When Recommended)

LUBRICATION SYSTEMS
UNIT I

JOB SHEET #1 CHANGE ENGINE OIL AND FILTER

I. Tools and materials

  A. Drain pan

  B. Wrench to fit drain plug

  C. Oil can spout

  D. Shop towels

  E. Safety glasses

II. Procedure

  A. Disconnect spark plug wire and ground

  B. Position drain pan under drain plug

  C. Remove drain plug (Figure 1)

  (NOTE: Oil should be drained when hot.)

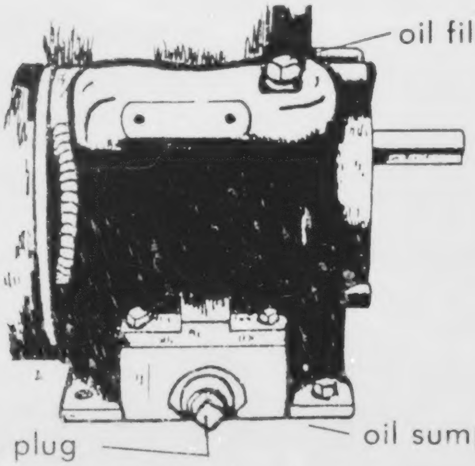


FIGURE 1

  D. Observe color and condition of oil

  (NOTE: Water and other contaminants might indicate problems in other areas.)

  E. Allow oil plenty of time to drain completely

  F. Change oil filter if required

JOB SHEET #1

G. Replace drain plug

(NOTE: Start with fingers and tighten adequately with wrench.)

H. Refill crankcase to recommended level with the proper engine oil (Figure 2)

(NOTE: Be sure filler can and spout are clean.)

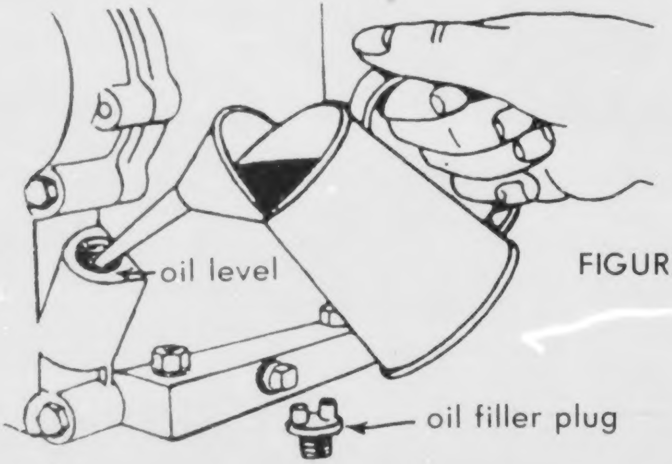


FIGURE 2

I. Clean and replace oil filler cap

J. Start engine and operate for a few minutes

K. Check for oil leaks

L. Shut off engine

M. Check oil level

(NOTE: Add oil if needed. Do not overfill.)

N. Have instructor check work

O. Clean up work area and replace tools in proper area

LUBRICATION SYSTEMS
UNIT I

JOB SHEET #2--SERVICE CRANKCASE BREATHER

I. Tools and materials

- A. Hand tool assortment
- B. Clean towels
- C. Solvent
- D. Container for cleaning parts
- E. New gasket
- F. Feeler gauge
- G. Safety glasses

II. Procedure

- A. Disconnect spark plug wire and ground
- B. Check breather for proper operation
- C. Remove crankcase breather cover if installed (Figure 1)

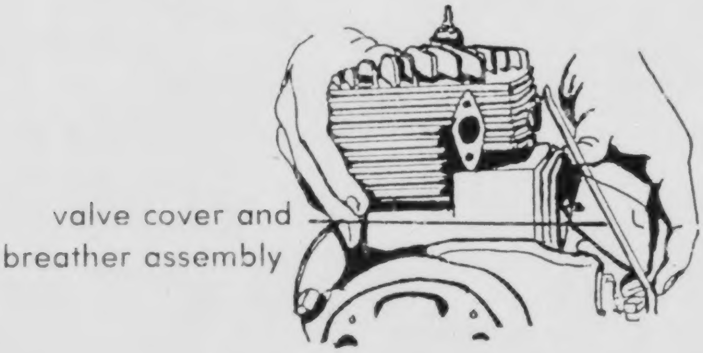


FIGURE 1

- D. Remove the crankcase breather if it is not a part of the cover

JOB SHEET #2

E. Check breather valve for clearance (Figure 2)

1. Check reed valves with a feeler gauge
2. Check manual for clearance specifications

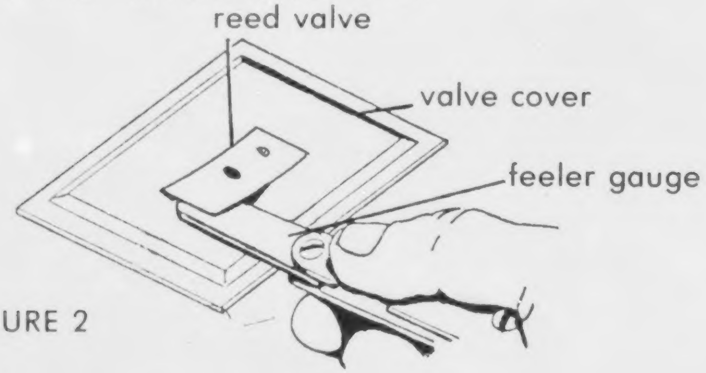

reed valve
valve cover
feeler gauge

FIGURE 2

F. Disassemble crankcase breather (Figure 3)

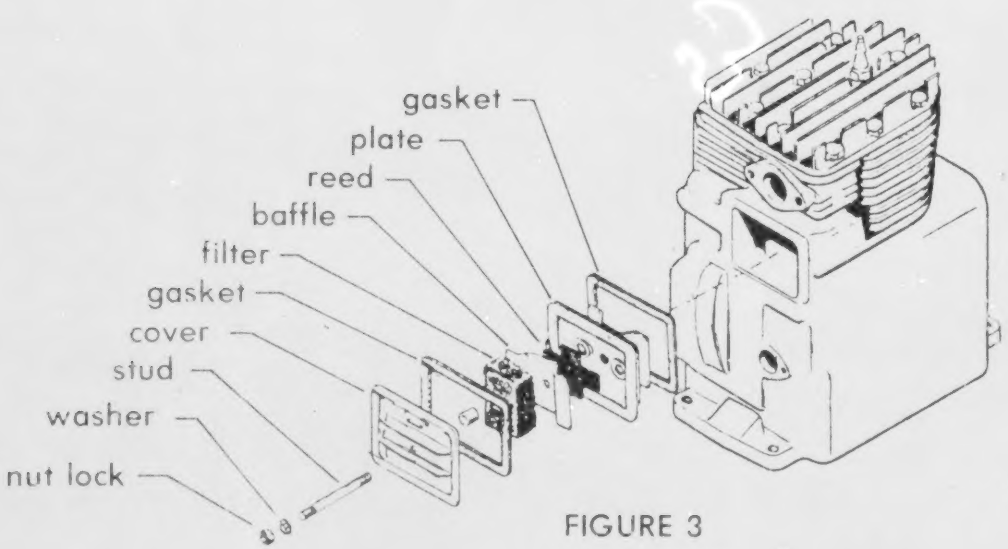

gasket
plate
reed
baffle
filter
gasket
cover
stud
washer
nut lock

FIGURE 3

G. Clean parts in solvent

H. Dry breather with compressed air

I. Replace breather and install new gaskets if needed

(NOTE: To prevent oil leaks, install parts in correct location.)

JOB SHEET #2

J. Run engine for a few minutes

K. Check for oil leaks

L. Shut off engine

M. Have instructor check work

N. Clean up work area and return tools to correct location

LUBRICATION SYSTEMS
UNIT I

NAME ____________________________

TEST

1. Match the terms on the right to the correct definitions.

______a. Certain chemicals added to oil to provide extra performance

______b. Oils compounded to behave as light oils at cold temperatures and heavy oils at warm temperatures

______c. Society of Automotive Engineers

______d. American Petroleum Institute

______e. Oil specifications prepared by the Ordnance Department of the Military Forces

______f. American Society for Testing Materials

______g. A measure of the fluidity of an oil at a given temperature

______h. Instrument used to measure the length of time in seconds required for a specified volume of oil to flow through a small orifice when the oil is brought to a specified temperature

______i. Device rotated by the camshafts for splashing oil

______j. Cover on the bottom of the engine block providing a reservoir for the engine oil

______k. Passageways in the engine used to carry oil from one area to another

______l. Device allowing the oil pump to pick up oil which is free from sediment in the oil pan

______m. Device used to remove abrasive particles from the oil

______n. Device fastened to connecting rod as a means of splashing oil

1. SAE
2. Viscosity
3. API
4. MIL
5. Viscometer
6. ASTM
7. Multi-grade oil
8. Additives
9. Oil pan (sump)
10. Oil filter
11. Slinger
12. Pressure relief valve
13. Oil gally (passage)
14. Dipper
15. Oil pickup

_____o. Valve in the lubrication system designed to limit maximum oil pressure

_____p. Gases under pressure leaking by the piston rings during combustion and the power stroke

_____q. Types of oils that are suitable for winter service

_____r. Heavy, thick residue found in the bottom of an oil pan caused by oil deterioration or oil contamination

_____s. Resistance to movement between two objects placed in contact with one another

16. "W" oils

17. Friction

18. Blow-by

19. Sludge

2. List five purposes of the lubrication system.

   a.

   b.

   c.

   d.

   e.

3. List the two main types of lubrication systems.

   a.

   b.

4. List four purposes of the crankcase breather.

   a.

   b.

   c.

   d.

5. Match the components of the crankcase breather on the right to the correct purposes.

______a. Keeps excessive oil from splashing onto filter

______b. Prevents entrance of excessive amounts of dirt

______c. Limits amount of fresh air entering crankcase and allows blow-by to leave engine

______d. Prevents dirt and abrasives from entering air

1. Cover (valve)
2. Filter
3. Baffle
4. Reed

6. List five functions of engine oil.

a.

b.

c.

d.

e.

7. Select the characteristics of a good engine oil by placing an "X" in the appropriate blanks.

______a. Keeps a protective film on moving parts

______b. Resists breakdown at high temperatures

______c. Resists corrosion and rusting

______d. Prevents carbon build-up

______e. Prevents sludge formation

______f. Flows easily at low temperatures

______g. Flows easily at high temperature

______h. Resists foaming

______i. Resists breakdown after long use

8. Discuss oil ratings and classifications.

a. SAE--

b. API--

c. MIL--

d. ASTM--

9. Explain the SAE viscosity number.

10. Explain the API classification system.

11. Name six oil contaminants.

a.

b.

c.

d.

e.

f.

12. Match the oil additives on the right to their functions.

______a. Helps prevent failure of alloy bearings from corrosive acids caused by combustion

______b. Prevents acid, varnish, and sludge formations

______c. Prevents rusting of metal parts during storage or downtime

______d. Helps oil give top lubricating protection at both high and low temperatures

______e. Prevents wax crystals from congealing in cold weather and forming clumps

______f. Assures lubrication where extreme pressures between close tolerances are encountered

______g. Helps keep metal surfaces clean and prevents deposit formation

______h. Helps prevent air bubbles which would restrict lubrication

1. Anti-rust
2. Oxidation inhibitor
3. Anti-corrosion
4. Viscosity index improver
5. Pour point depressant
6. Extreme pressure
7. Foam inhibitor
8. Detergent-dispersant

13. Select the factual statements about oil by placing an "X" in the appropriate blanks.

______a. Oil becomes unfit for further use as it absorbs contaminants and as additives are depleted

______b. Multi-viscosity oils are not always preferred

______c. Black oil does not mean time for an oil change

______d. Buy quality oil filters as recommended by machine operator's manual

______e. Oil oxidation results in thicker oil

______f. Using a light oil until consumption increases, and then switching to a heavier oil, is not a good practice

______g. Following operator's manual recommendations is critical to insure good performance

14. List five general rules for selection and use of oils for best engine performance.

a.

b.

c.

d.

e.

15. Discuss the two cycle oil selection and use.

16. List two ways to avoid oil contamination.

a.

b.

17. Demonstrate the ability to:

a. Change engine oil and filter.

b. Service crankcase breather.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

LUBRICATION SYSTEMS
UNIT I

ANSWERS TO TEST

1. a. 8
   b. 7
   c. 1
   d. 3
   e. 4
   f. 6
   g. 2
   h. 5
   i. 11
   j. 9
   k. 13
   l. 15
   m. 10
   n. 14
   o. 12
   p. 18
   q. 16
   r. 19
   s. 17

2. a. Reduces friction
   b. Cools engine parts
   c. Absorbs shock and reduces engine noise
   d. Forms seal between piston rings and cylinder walls
   e. Acts as a cleansing agent

3. a. Splash system
   b. Pump system

4. a. Allows blow-by to escape
   b. Limits corrosion of engine parts
   c. Prevents oil leaks at seals and gaskets by relieving crankcase pressure
   d. Allows entrance of fresh air

5. a. 3
   b. 1
   c. 4
   d. 2

6. a. Reduces friction and wear
   b. Cools moving parts
   c. Helps seal cylinders
   d. Keeps parts clean
   e. Cushions moving parts

7. a, b, c, d, e, f, h, i

8. Discussion should include:
   a. SAE--Viscosity established by Society of Automotive Engineers
   b. API--Service classification established by American Petroleum Institute
   c. MIL--Specifications prepared by Ordnance Department of U.S. Army, Navy, and Air Force
   D. ASTM--Engine sequence tests whose procedures are adopted by the American Society for Testing Materials

9. Explanation should include:
   a. Oils vary in viscosity as temperatures change
   b. Lighter oils for winter use are specified at 0°F and carry a 5w, 10w, or 20w symbol
   c. Heavier oils are specified at 210°F and carry a 20, 30, 40, or 50 viscosity number

10. Explanation should include:
    a. Joint effort of API, ASTM, and SAE organizations
    b. Attempts to clarify oil specifications and oil qualities between the engine manufacturer, the petroleum industry, and the customer

11. a. Foreign Particles
    b. Water
    c. Antifreeze
    d. Fuel
    e. Oxidation
    f. Acids

12. a. 3
    b. 2
    c. 1
    d. 4
    e. 5
    f. 6
    g. 8
    h. 7

13. a, b, c, d, e, f, g

14. Any five of the following:

    a. Use brands which meet engine manufacturer's specifications

    b. Drain and change at recommended intervals

    c. Select oils which have been performance tested

    d. Never mix oils of various MIL or API specifications

    e. Bring engine up to normal operating temperature each time it is used

    f. Keep oil containers covered, sealed, and protected to prevent contamination

15. Discussion should include:

    a. Selection

        1) Select only manufacturer's recommended SAE rating

        2) Select only oil recommended for use in either air cooled or water cooled two cycle engines

    b. Use

        1) Use oil-fuel mixture recommended by manufacturer

        2) Use oils that meet or exceed manufacturer's recommendations

16. Any two of the following:

    a. Drain oil at recommended intervals

    b. Use clean oil containers and work habits

    c. Replace or clean filters before they become plugged

17. Performance skills evaluated to the satisfaction of the instructor

COOLING SYSTEMS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to list the functions of the cooling system and identify the components of the cooling system. The student should also be able to remove, clean, and replace air cooling parts, and pressure test the cooling system. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match the terms associated with cooling systems to the correct definitions.
2. List three functions of the cooling system.
3. Identify the components of the cooling system.
4. Match the components of the cooling system to their functions.
5. Demonstrate the ability to:
    a. Remove, clean, and replace air cooling parts.
    b. Pressure test the cooling system.
    c. Remove, check, and replace a thermostat.
    d. Remove and replace a water pump.
    e. Remove and replace a radiator.
    f. Remove, inspect, and replace V-belts.
    g. Test antifreeze solution.

COOLING SYSTEMS
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information and job sheets.

  F. Demonstrate both types of cooling systems on engine.

  G. Assist students in identification of components on live engines.

  H. Demonstrate and discuss the procedures outlined in the job sheets.

  I. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete job sheets.

  D. Compare cooling systems on different types of engines.

  E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Parts of an Air Cooled System

    2. TM 2--Parts of a Liquid Cooling System

D. Job sheets

1. Job Sheet #1--Remove, Clean, and Replace Air Cooling Parts
2. Job Sheet #2--Pressure Test the Cooling System
3. Job Sheet #3--Remove, Check, and Replace a Thermostat
4. Job Sheet #4--Remove and Replace a Water Pump
5. Job Sheet #5--Remove and Replace a Radiator
6. Job Sheet #6--Remove, Inspect, and Replace V-Belts
7. Job Sheet #7--Test Antifreeze Solution

E. Test

F. Answers to test

II. References:

A. *Small Engines, Volume I.* Athens, Georgia: American Association for Vocational Instructional Materials, 1971.

B. Roth, Alfred C. *Small Gas Engines.* South Holland, Illinois: Goodheart-Willcox Co., Inc., 1975.

COOLING SYSTEMS
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Conduction--Heat transfer through a solid material

B. Convection--Heat transfer through movement of a gas

(NOTE: In cooling systems, transfer is through air.)

C. Radiation--Process of emitting radiant energy in the form of waves or particles

D. Shroud--Cover over blower (flywheel) that directs air to the engine fins

E. Baffle--Cover over the finned area of the engine to hold the air around the fins

F. Fin--Protrusions cast on the head and cylinder to provide increased surface for additional cooling area

G. Water jacket--Passage through the block and cylinder head that allows the coolant to circulate around the cylinder, valves, and combustion chamber

H. Radiator--Device for holding coolant in close contact with a large amount of air so that heat may be transferred from the coolant to the air

I. Thermostat--Heat controlled valve used in the cooling system to regulate the flow of coolant between the cylinder block and radiator

J. Water pump--Device mounted at the front of the cylinder block to circulate the coolant throughout the cooling system

K. Cooling system--Components designed to keep the engine at its most efficient operating temperature during engine operation

II. Functions of the cooling system

A. Removes surplus or unwanted heat

B. Maintains efficient operating temperature under all operating conditions

C. Brings an engine, when started, up to operating temperature as soon as possible

INFORMATION SHEET

III. Components of the cooling systems

A. Air cooled (Transparency 1)

1. Flywheel
2. Filter screen
3. Blower shroud
4. Cylinder head baffle
5. Cylinder baffle
6. Air deflector

B. Liquid cooled (Transparency 2)

1. Radiator
2. Water pump
3. Water jacket
4. Fan
5. Thermostat
6. Pressure cap
7. Radiator hose
8. Fan belt

IV. Components and functions of the cooling system

A. Air cooled

1. Flywheel--Device used to move a large volume of air to the engine

2. Filter screen--Covering on outside of flywheel to filter out large materials in the air stream

   (NOTE: These are such materials as leaves and grass.)

3. Shroud and baffles--Covers flywheel and directs air over the engine fins to promote cooling

INFORMATION SHEET

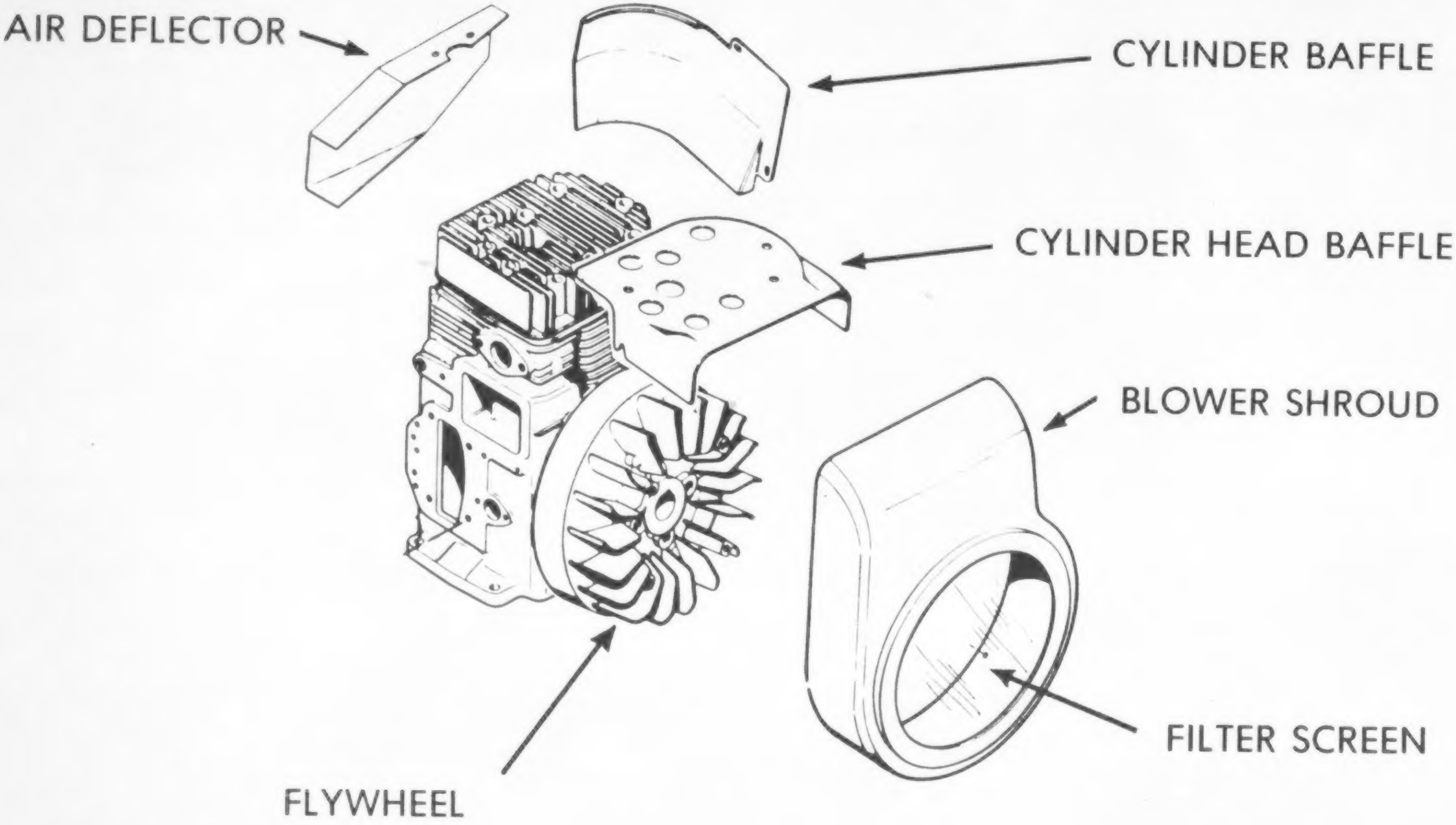
B. Liquid cooled

1. Radiator--Removes heat from the coolant by conduction, radiation, and convection
2. Water pump--Pushes water heated by the engine through the radiator
3. Water jacket--Allows circulation of coolant around cylinder, where it absorbs combustion heat
4. Fan--Forces cooling air through the radiator fins
5. Thermostat--Regulates the flow of coolant
6. Pressure cap--Prevents coolant from escaping and allows atmospheric pressure to enter cooling system

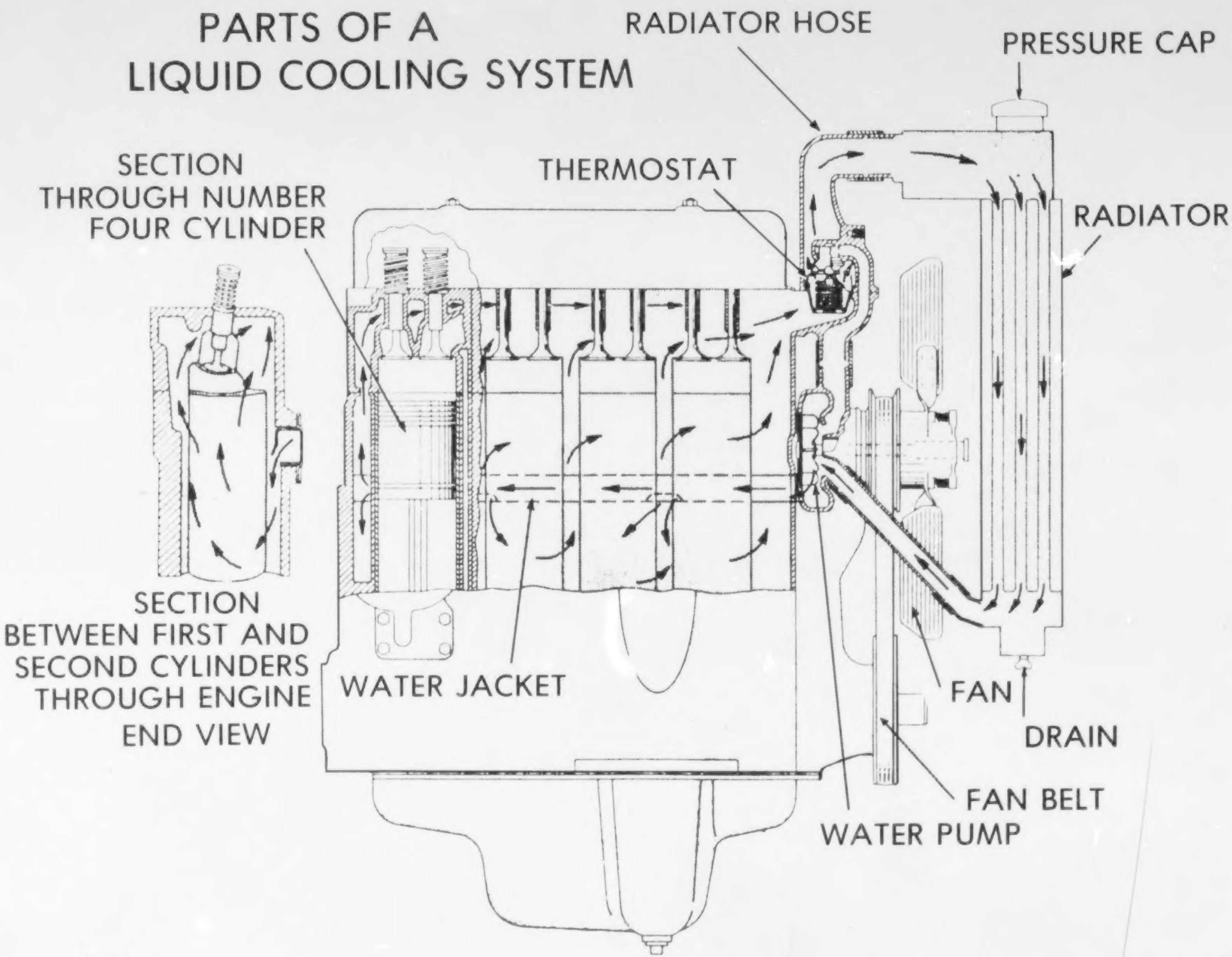
   (NOTE: The pressure rating of the cap affects the boiling point of the coolant. Each pound of rating raises the boiling point of water about 3 degrees F.)

7. Radiator hose--Transfers coolant from the thermostat housing to radiator and from radiator to water pump
8. Fan belt--Drives fan and water pump from pulley on engine crankshaft

PARTS OF AN AIR COOLED SYSTEM


AIR DEFLECTOR
CYLINDER BAFFLE
CYLINDER HEAD BAFFLE
BLOWER SHROUD
FILTER SCREEN
FLYWHEEL

PARTS OF A LIQUID COOLING SYSTEM


RADIATOR HOSE
PRESSURE CAP
SECTION THROUGH NUMBER FOUR CYLINDER
THERMOSTAT
RADIATOR
SECTION BETWEEN FIRST AND SECOND CYLINDERS THROUGH ENGINE END VIEW
WATER JACKET
FAN
DRAIN
FAN BELT
WATER PUMP

COOLING SYSTEMS
UNIT II

JOB SHEET #1 REMOVE, CLEAN, AND REPLACE AIR COOLING PARTS

I. Tools and materials

- A. Hand tool assortment
- B. Wire brush
- C. Parts scraper
- D. Wooden scraper
- E. Cleaning solvent
- F. Parts cleaning brush
- G. Small hand sprayer
- H. Safety glasses
- I. Water hose
- J. Compressed air

II. Procedure

- A. Remove blower shroud
- B. Remove baffles
- C. Pour solvent into sprayer
- D. Spray solvent over dirty fins and block areas (Figure 1)

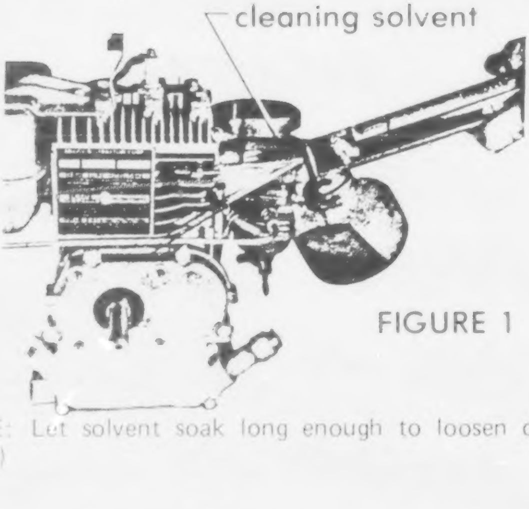


FIGURE 1

(NOTE: Let solvent soak long enough to loosen caked or dried dirt or grease.)

JOB SHEET #1

E. Wash engine with clear water (Figure 2)

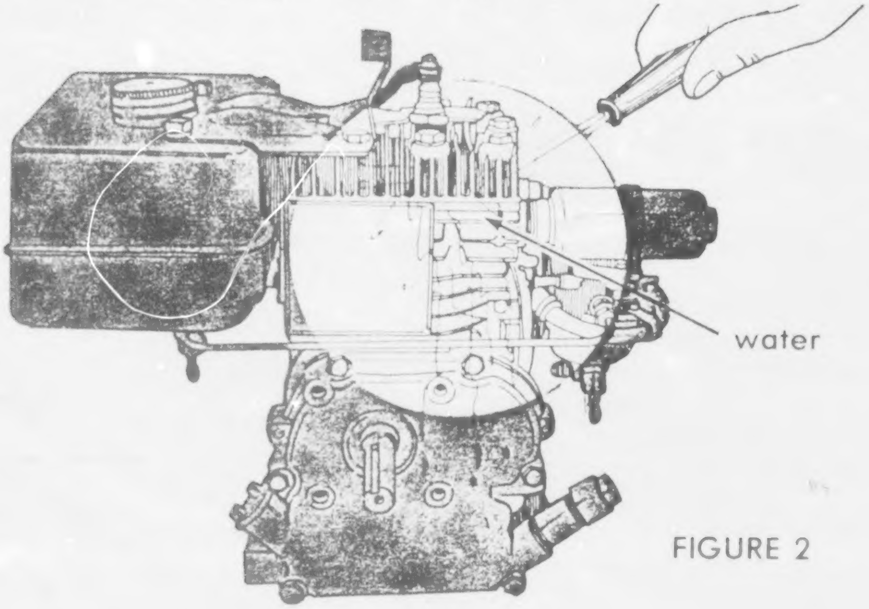


FIGURE 2

F. Scrape areas that have hard to remove accumulations of dirt or grease (Figures 3 and 4)

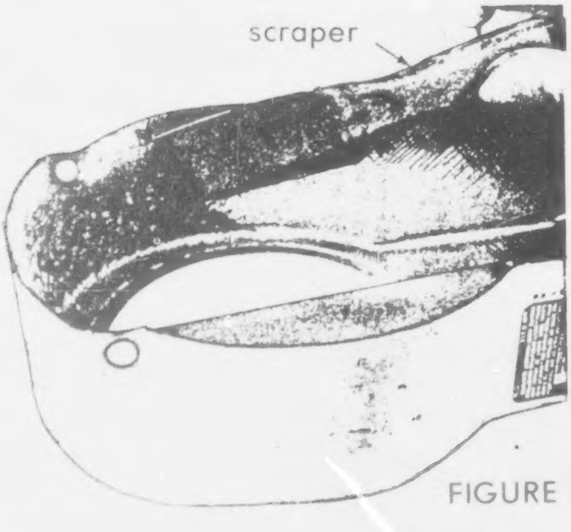


FIGURE 3

(NOTE: Use wooden scrapers on aluminum areas like newer engine blocks and fins.)

JOB SHEET #1

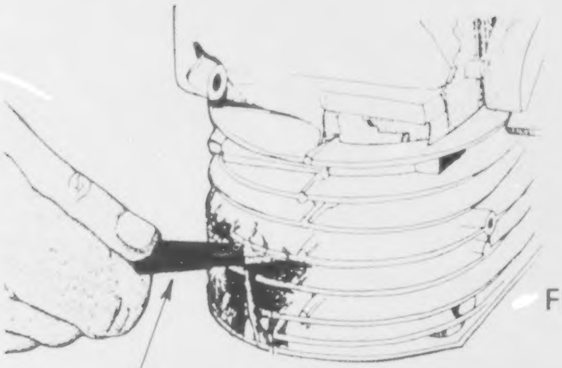

wooden scraper

FIGURE 4

G. Clean flywheel fins

H. Clean air intake screen with parts cleaning brush (Figure 5)

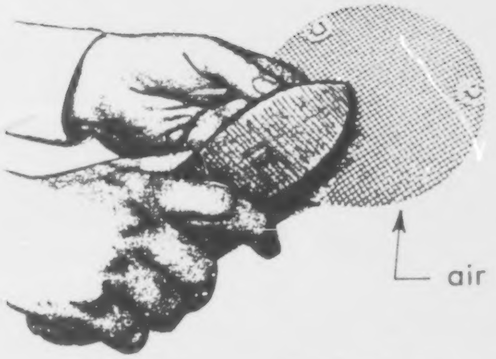

air intake screen

FIGURE 5

I. Dry engine with compressed air

J. Inspect all baffles, shroud, and screen for damage

K. Reassemble cooling system

L. Have instructor evaluate your work

COOLING SYSTEMS
UNIT II

JOB SHEET #2--PRESSURE TEST THE COOLING SYSTEM

I. Tools and materials

   A. Radiator pressure tester

   B. Safety glasses

II. Procedure

   A. Remove radiator cap

   (CAUTION: Never remove the radiator cap quickly when the engine is hot. If cap must be removed when hot, loosen cap to first stop and leave in this position until all pressure is released. Cap can then be removed safely.)

   B. Wipe the radiator filler cap seat clean

   C. Attach the radiator pressure tester

   D. Apply pressure (Figure 1)

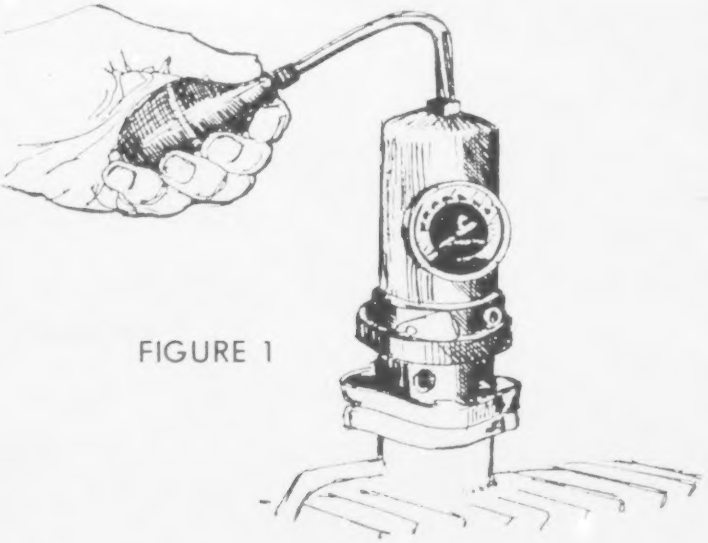


FIGURE 1

   (NOTE: Pressure applied should not exceed recommended cooling system pressure by more than 1 psi.)

   E. Watch pressure indicator

   (NOTE: The cooling system is not leaking if pressure remains steady.)

JOB SHEET #2

F. Inspect system if pressure drops

1. Check for external leaks in hose connections, expansion plugs, water pump, and radiator

2. Check for internal leaks

   a. Remove tester

   b. Start and run engine until operating temperature is reached

   (NOTE: Look inside cap opening. Bubbles indicate compression escaping into cooling system.)

   c. Reattach pressure tester

   d. Apply cooling system pressure

   e. Increase engine speed to half-throttle

      a) If pressure gauge needle fluctuates, this indicates a combustion leak

      (NOTE: If combustion leaks are evident, the engine will have to be disassembled for repairs.)

      b) If pressure gauge needle does not fluctuate, sharply accelerate engine several times and check for a discharge of water from the tail pipe

      (NOTE: If an abnormal amount of water is discharged at the tail pipe, this could indicate a cracked block or head or a defective head gasket.)

G. Remove tester and make appropriate repairs

H. Test the pressure cap (Figure 2)

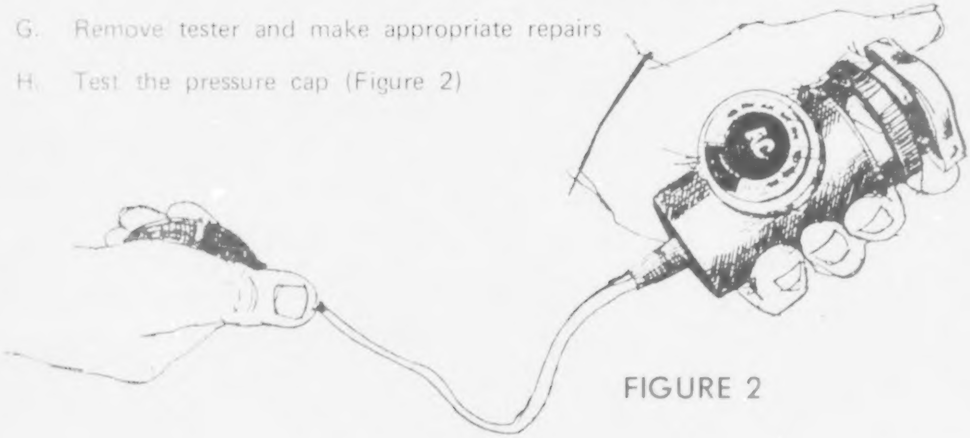


FIGURE 2

(NOTE: Use the radiator pressure tester with adapter. If the cap does not hold the rated pressure, it should be replaced.)

JOB SHEET #2

I. Refill system with coolant

J. Reinstall cap

COOLING SYSTEMS
UNIT II

JOB SHEET #3 REMOVE, CHECK, AND REPLACE A THERMOSTAT

I. Tools and materials

A. Drain pan

B. Hose clamp pliers

C. Hand tool assortment

D. High temperature thermometer

E. Gasket scraper

F. Gasket sealer

G. Torque wrench

H. Radiator fill can

I. Safety glasses

II. Procedure

A. Drain coolant to a level below thermostat

B. Remove radiator hose connected to thermostat outlet if required

C. Remove the thermostat housing retaining bolts

D. Remove the thermostat housing

E. Remove thermostat

F. Determine condition of thermostat

(NOTE: Discard thermostat if it is excessively rusted, bent, or stuck in an open position.)

G. Check thermostat opening

JOB SHEET #3

1. Suspend thermostat in a container of water with a high temperature thermometer (Figure 1)

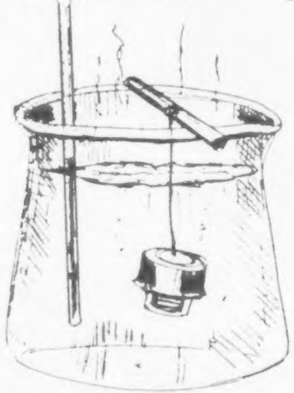


FIGURE 1

2. Heat the container

3. Observe the temperature at which the thermostat begins to open and the temperature at full open position

   a. Discard thermostat if it fails to respond at specified temperatures

      (NOTE: Check manufacturer's specifications for temperatures at which the thermostat should start to open.)

   b. Reinstall thermostat if it checks okay

H. Clean thermostat seat and thermostat housing

(NOTE: Remove all traces of gasket and rust.)

I. Place thermostat into thermostat opening (Figure 2)

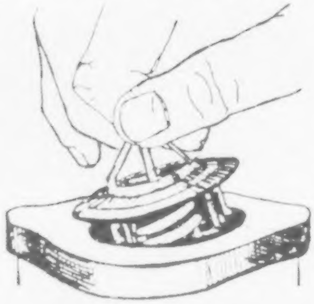


FIGURE 2

(NOTE: Make sure bellows or spring on thermostat is placed toward the cylinder block.)

J. Install new gasket with gasket sealer as required

K. Install thermostat housing; start retaining bolts

JOB SHEET #3

L. Tighten bolts uniformly and to specified torque

M. Install hose and tighten clamps securely

N. Fill cooling system

(NOTE: Bleed the system according to manufacturer's specifications.)

O. Start engine

P. Check for leaks

Q. Recheck the coolant level after the engine is warm

COOLING SYSTEMS
UNIT II

JOB SHEET #4 REMOVE AND REPLACE A WATER PUMP

I. Tools and materials

   A. Drain pan

   B. Hand tool assortment

   C. Hose clamp pliers

   D. Parts scraper

   E. Gasket sealer

   F. Torque wrench

   G. Screwdriver

   H. Radiator fill can

   I. Safety glasses

II. Procedure

   A. Remove water pump

      1. Drain cooling system

      2. Remove drive belts

      3. Remove fan

         (NOTE: Usually the fan must be removed before the fan shroud.)

      4. Remove fan shroud

      5. Determine type of water pump

         (NOTE: Some water pumps are small and are attached to the front engine housing. Other pumps are attached to the block and require lower hose removal.)

      6. Remove lower hose if required

      7. Remove water pump retainer bolts

JOB SHEET #4

8. Remove water pump
9. Clean gasket material and rust from gasket surfaces

B. Replace water pump

1. Apply gasket sealer to gasket surfaces
2. Place gasket on water pump

   (NOTE: Sometimes it will be necessary to place the gasket on the block for convenience of installation.)

3. Replace water pump
4. Start retainer bolts
5. Tighten water pump retainer bolts uniformly; torque to specifications
6. Replace lower hose if removed
7. Replace fan shroud if used
8. Replace fan assembly

   (NOTE: Make sure fan is placed correctly to draw air through the radiator.)

9. Replace drive belts
10. Adjust belts to manufacturer's specifications
11. Close radiator drain
12. Fill radiator with coolant

    (NOTE: Bleed system according to manufacturer's specifications.)

13. Start engine and allow warm-up time
14. Check for leaks

    (NOTE: Follow manufacturer's recommended procedure for water pump break-in.)

COOLING SYSTEMS
UNIT II

JOB SHEET #5-REMOVE AND REPLACE A RADIATOR

I. Tools and materials

   A. Hose clamp pliers

   B. Hand tool assortment

   C. Safety glasses

   D. Drain pan

II. Procedure

   A. Drain radiator liquid into pan

   B. Disconnect upper radiator hose from radiator

   C. Disconnect lower radiator hose from radiator

   D. Remove fan shroud attaching screws

   E. Move fan shroud toward the engine back over the fan assembly

   F. Remove radiator attaching bolts

   G. Remove radiator

   H. Clean air passages using compressed air

   I. Check the radiator mounting shell for breaks or cracks

   J. Replace the radiator

   (NOTE: Make sure fan shroud is in place before radiator is replaced.)

   K. Position radiator; start attaching bolts

   L. Tighten radiator attaching bolts

   M. Move fan shroud into place, install attaching screws, and tighten securely

   N. Inspect hoses to determine if replacement is necessary

   O. Replace lower hose and tighten clamps securely

   P. Replace upper hose and tighten clamps securely

   Q. Close radiator drain cock

JOB SHEET #5

R. Refill radiator with recommended coolant

(NOTE: Bleed system according to manufacturer's specifications.)

S. Start engine and allow to warm-up

T. Check for coolant leaks

U. Check coolant level

COOLING SYSTEMS
UNIT II

JOB SHEET #6 REMOVE, INSPECT, AND REPLACE V-BELTS

I. Tools and materials

   A. Hand tool assortment

   B. Pry bar

   C. V-belt tension gauge

   D. Safety glasses

II. Procedure

   A. Locate slotted adjustment holes on brace or component to be adjusted

   B. Loosen necessary bolts to allow component movement

   C. Move component toward block to allow V-belt removal

   D. Inspect V-belt

   (NOTE: Inspect for cracks, glazing, fraying, or any condition that will make the belt unreliable or inefficient to use.)

   E. Replace V-belt

   F. Adjust belt tension to manufacturer's specifications (Figure 1)

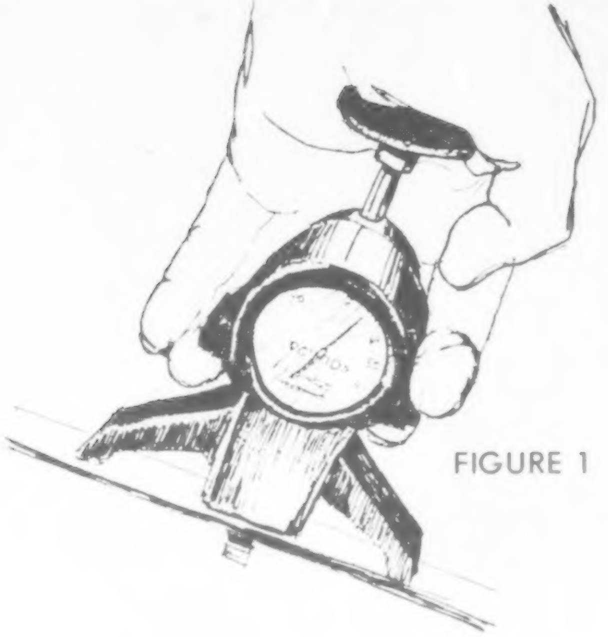


FIGURE 1

JOB SHEET #6

(NOTE: Tension can also be checked by measuring the amount of belt defection; check manufacturer's specifications for proper defection. If specifications and tension gauge are not available the short and long run slack examples below may be used. See Figure 2.)

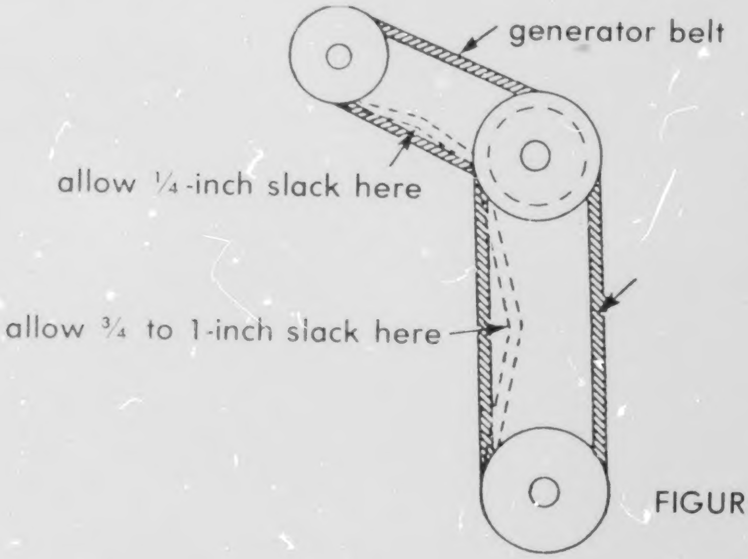

generator belt
allow ¼-inch slack here
allow ¾ to 1-inch slack here

FIGURE 2

G. Hold tension on belt and tighten all brackets and braces securely

H. Recheck tension

(NOTE: It will be necessary to readjust new belts after a few hours of operation due to stretching.)

COOLING SYSTEMS
UNIT II

JOB SHEET #7 TEST ANTIFREEZE SOLUTION

I. Materials--Antifreeze hydrometer tester

II. Procedure

A. Start engine and allow time for coolant to warm up to operating temperature

B. Remove radiator cap

(CAUTION: Never remove the radiator cap quickly when the engine is hot. Loosen cap slowly to first stop and leave in this position until all pressure is released. Cap can then be removed safely.)

C. Draw coolant into tester and empty several times to equalize the temperature of all parts

D. Draw coolant into tester

E. Read the first number or letter on the float above the liquid surface

F. Note temperature of coolant

G. Measure antifreeze content of the water by comparing the reading with the chart on the tester

(NOTE: The antifreeze content should be such that the cooling system would be protected to 10°F [5°C] lower than the coldest temperature expected.)

H. Add antifreeze if necessary

(NOTE: Allow room for expansion.)

COOLING SYSTEMS
UNIT II

TEST

1. Match the terms on the right to the correct definitions.

_____a. Heat transfer through a solid material

_____b. Cover over the finned area of the engine to hold the air around the fins

_____c. Device for holding coolant in close contact with a large amount of air so that heat may be transferred from the coolant to the air

_____d. Protrusions cast on the head and cylinder to provide increased surface for additional cooling area

_____e. Cover over blower (flywheel) that directs air to the engine fins

_____f. Heat transfer through movement of a gas

_____g. Passage through the block and cylinder head that allows the coolant to circulate around the cylinder, valves, and combustion chamber

_____h. Device mounted at the front of the cylinder block to circulate the coolant throughout the cooling system

_____i. Heat controlled valve used in the cooling system to regulate the flow of coolant between the cylinder block and radiator

_____j. Process of emitting radiant energy in the form of waves or particles

_____k. Components designed to keep the engine at its most efficient operating temperature during engine operation

1. Fin
2. Water jacket
3. Baffle
4. Water pump
5. Thermostat
6. Radiator
7. Conduction
8. Convection
9. Cooling system
10. Shroud
11. Radiation

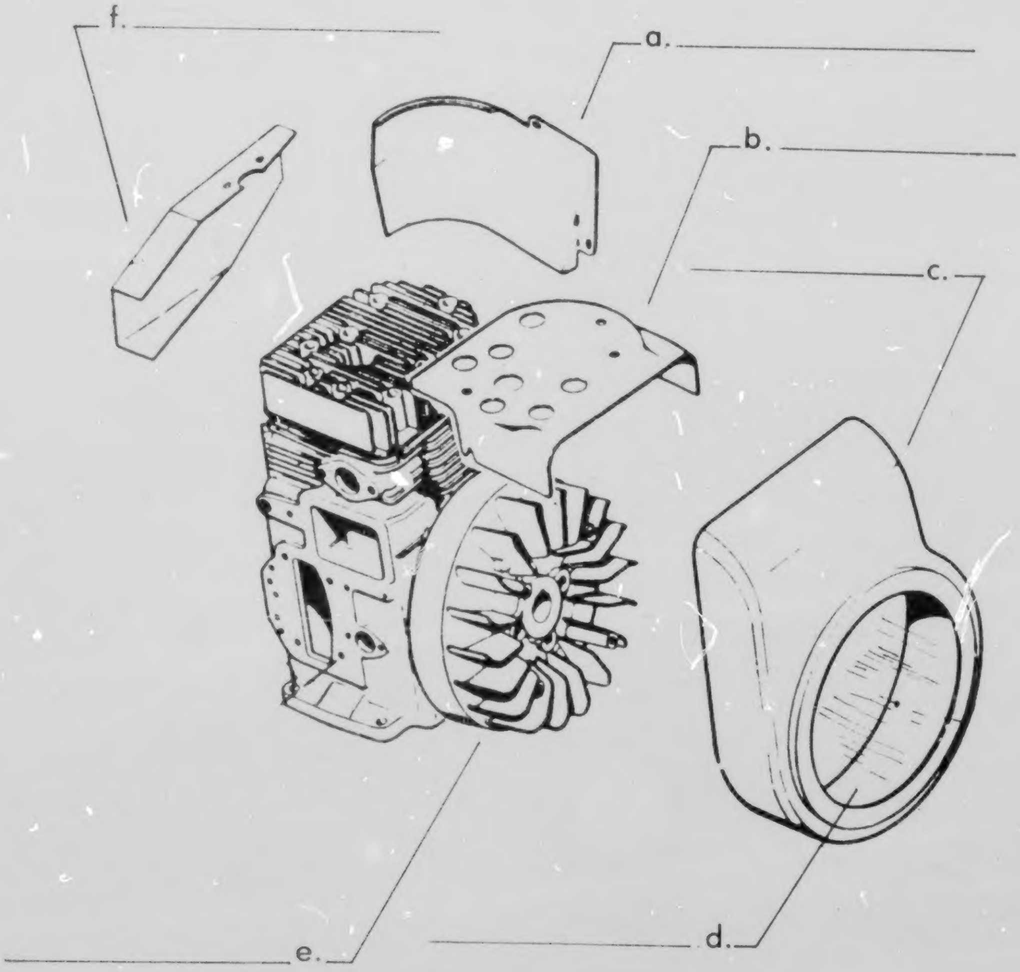
2. List three functions of the cooling system.

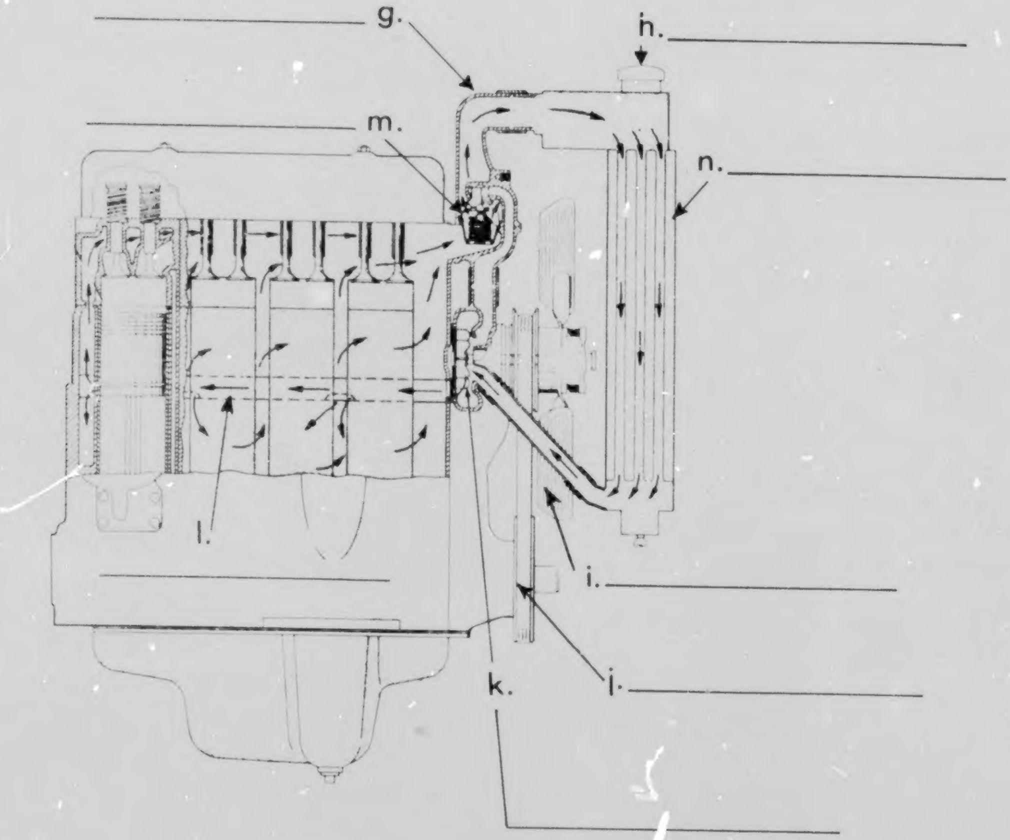
   a.

   b.

   c.

3. Identify the components of the cooling system.





4. Match the components of the cooling system on the right to their correct functions.

______a. Pushes water heated by the engine through the radiator

______b. Device used to move a large volume of air to the engine

______c. Drives fan and water pump from pulley on engine crankshaft

1. Radiator
2. Flywheel
3. Water jacket
4. Thermostat
5. Fan belt

_____d. Prevents coolant from escaping and allows atmospheric pressure to enter cooling system

_____e. Covering on outside of flywheel to filter out large materials in the air stream

_____f. Covers flywheel and directs air over the engine fins to promote cooling

_____g. Transfers coolant from the thermostat housing to radiator and from radiator to water pump

_____h. Regulates the flow of coolant

_____i. Forces cooling air through the radiator fins

_____j. Allows circulation of coolant around cylinder, where it absorbs combustion heat

_____k. Removes heat from the coolant by conduction, radiation, and convection

6. Radiator hose
7. Filter screen
8. Shroud and baffles
9. Water pump
10. Fan
11. Pressure cap

5. Demonstrate the ability to:

   a. Remove, clean, and replace air cooling parts.

   b. Pressure test the cooling system.

   c. Remove, check, and replace a thermostat.

   d. Remove and replace a water pump.

   e. Remove and replace a radiator.

   f. Remove, inspect, and replace V-belts.

   g. Test antifreeze solution.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

COOLING SYSTEMS
UNIT II

ANSWERS TO TEST

1.
   a. 7
   b. 3
   c. 6
   d. 1
   e. 10
   f. 8
   g. 2
   h. 4
   i. 5
   j. 11
   k. 9

2.
   a. Removes surplus or unwanted heat
   b. Maintains efficient operating temperature under all operating conditions
   c. Brings an engine, when started, up to operating temperature as soon as possible

3.
   a. Cylinder baffle
   b. Cylinder head baffle
   c. Blower shroud
   d. Filter screen
   e. Flywheel
   f. Air deflector
   g. Radiator hose
   h. Pressure cap
   i Fan
   j. Fan Belt
   k. Water pump
   l. Water jacket
   m. Thermostat
   n. Radiator

4.
   a. 9
   b. 2
   c. 5
   d. 11
   e. 7
   f. 8
   g. 6
   h. 4
   i. 10
   j. 3
   k. 1

5. Performance skills evaluated to the satisfaction of the instructor.

FUEL SYSTEMS
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to list the purpose of each of the components of the fuel system and describe the fuel pump action. The student should also be able to remove, replace, and service a carburetor and a fuel pump and service an air cleaner. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the fuel system to the correct definitions.
2. State the purpose of the fuel system.
3. List the three basic types of small engine fuel supply systems.
4. List the purpose of each of the components of the fuel system.
5. Identify three types of fuel filters.
6. Describe the fuel pump action during the inlet and outlet strokes.
7. Identify three types of air cleaners.
8. Identify parts of the carburetor.
9. Match the carburetor systems to the correct statements of their use.
10. Demonstrate the ability to:
    a. Service an air cleaner.
    b. Remove and replace a carburetor.
    c. Service float type carburetor.
    d. Remove and replace a fuel pump.
    e. Test and service a fuel pump.
    f. Service sediment bowl fuel strainer.

FUEL SYSTEMS
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Show worn or damaged carburetor parts.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Fuel Supply Systems

      2. TM 2--Fuel Filter - Filter Attached to End of Flexible Fuel Hose

      3. TM 3--Fuel Filter - Sediment Bowl

      4. TM 4--Fuel Filter - Screen in Fuel Tank

   5. TM 5--Fuel Pump
   6. TM 6--Fuel Pump (Continued)
   7. TM 7--Air Cleaners
   8. TM 8--Parts of a Float Carburetor
   9. TM 9--The Float System
   10. TM 10--Float Type Carburetor
   11. TM 11--Carburetor Choke Valve
   12. TM 12--The Choke System
   13. TM 13--The High Speed System
   14. TM 14--The Idle System
   15. TM 15--Bulb Type Primer

D. Job sheets

   1. Job Sheet #1--Service an Air Cleaner
   2. Job Sheet #2--Remove and Replace a Carburetor
   3. Job Sheet #3--Service Float Type Carburetor
   4. Job Sheet #4--Remove and Replace a Fuel Pump
   5. Job Sheet #5--Test and Service a Fuel Pump
   6. Job Sheet #6--Service Sediment Bowl Fuel Strainer

E. Test

F. Answers to test

II. References:

A. Roth, Alfred C. *Small Gas Engines*. South Holland, Illinois: Goodheart-Willcox Co., Inc., 1975.

B. Hendrix, Laborn. *Cement Masonry*. Stillwater, Oklahoma: Curriculum and Instructional Materials Center/State Department of Vocational and Technical Education and Associated General Contractors, 1974.

FUEL SYSTEMS
UNIT III

INFORMATION SHEET

I. Terms and definitions

  A. Venturi--Restriction in the carburetor which makes the air speed up, causing a high vacuum

  B. Airfoil--Tube in a stream of air inside the venturi which creates an air pattern with low pressure on one side

  C. Atomization--Breaking of a liquid into tiny particles or globules to aid vapor formation

  D. Metering--Correct proportion of fuel and air needed for good combustion

  E. Vaporization--Transferring a substance into a gaseous state

II. Purpose of the fuel system--The fuel system supplies a combustible mixture of air and fuel vapor to the engine cylinder(s)

III. Basic types of small engine fuel supply systems (Transparency 1)

  A. Gravity feed

  B. Suction feed

  C. Pump feed

IV. Components of the fuel system

  A. Fuel tank--Acts as reservoir to store fuel for engine use

  B. Fuel filter--Prevents dirt or foreign matter from entering the carburetor

  C. Carburetor--Automatically mixes fuel and air in the proper proportion for a combustible mixture

  D. Fuel pump--Pumps fuel from the fuel tank to the carburetor

  E. Fuel line--Carries fuel from the fuel tank to the carburetor

  F. Air cleaner--Filters grit and dust from the air entering the carburetor

INFORMATION SHEET

V. Types of fuel filters (Transparencies 2, 3, and 4)

  A. Sediment bowl

  B. Screen in fuel tank

  C. Filter attached to the end of flexible fuel hose (in tank)

VI. Fuel pump action (Transparencies 5 and 6)

  A. Inlet stroke

    1. Diaphragm flexes downward, forming a vacuum

    2. Inlet check valve opens

    3. Fuel is drawn into pump

  B. Outlet stroke

    1. Diaphragm pushed upward by return spring

    2. Inlet valve forced shut

    3. Outlet valve forced open

    4. Fuel is forced out of pump

VII. Types of air cleaners (Transparency 7)

  A. Oil bath

  B. Paper element

  C. Polyurethane

VIII. Parts of the carburetor (Transparency 8)

  A. Fuel inlet

  B. Float needle seat

  C. Float needle

  D. Float

  E. Nozzle

  F. Packing nut

INFORMATION SHEET

G. Needle valve

H. Throttle valve

I. Idle valve

J. Venturi

K. Choke valve

(NOTE: These parts are for a float type carburetor.)

IX. Carburetor systems (Transparencies 9, 10, 11, 12, 13, 14, and 15)

A. Float--Maintains a given depth of fuel in the float chamber

B. Choke--Provides a richer mixture for cold engine starting and operation

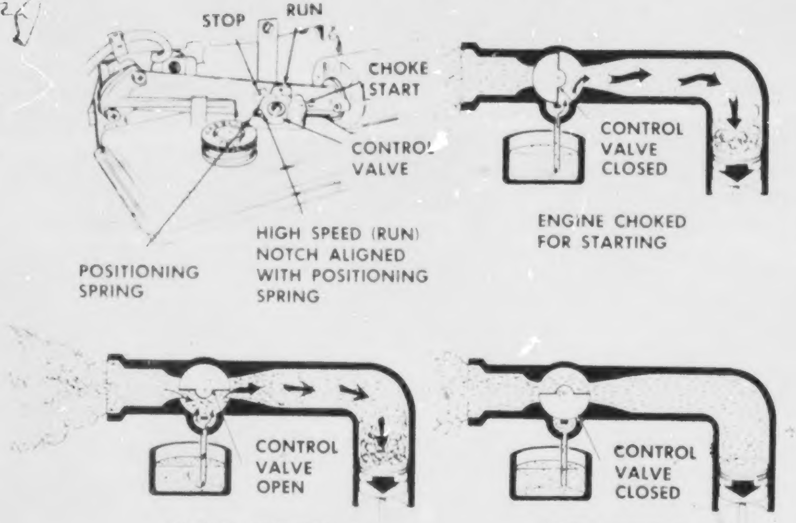
C. High speed--Used when the engine is called upon to supply power for full, partial, or no-load at various operating speeds

D. Idle speed--Provides fuel delivery during closed or nearly closed throttle operation

E. Throttle--Used to control the speed or power of an engine according to the requirements of the job it is to perform

FUEL SUPPLY SYSTEMS

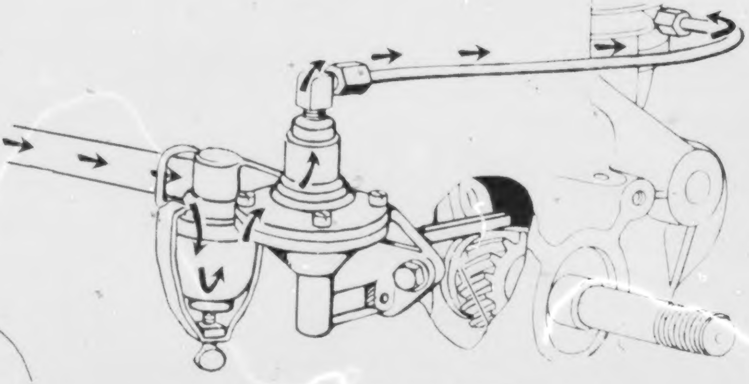
SUCTION-LIFT TYPE CARBURETOR


STOP
RUN
CHOKE
START
CONTROL VALVE
POSITIONING SPRING
HIGH SPEED (RUN) NOTCH ALIGNED WITH POSITIONING SPRING
CONTROL VALVE CLOSED
CONTROL VALVE OPEN
CONTROL VALVE CLOSED

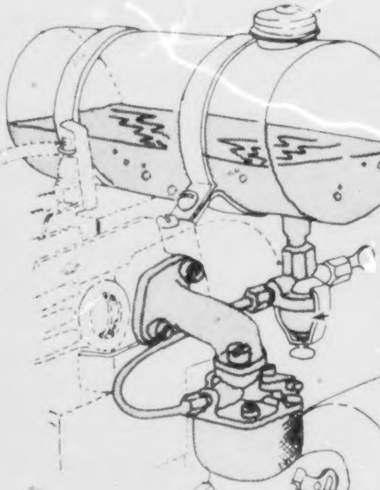
ENGINE CHOKED FOR STARTING

ENGINE RUNNING

ENGINE STOPPED



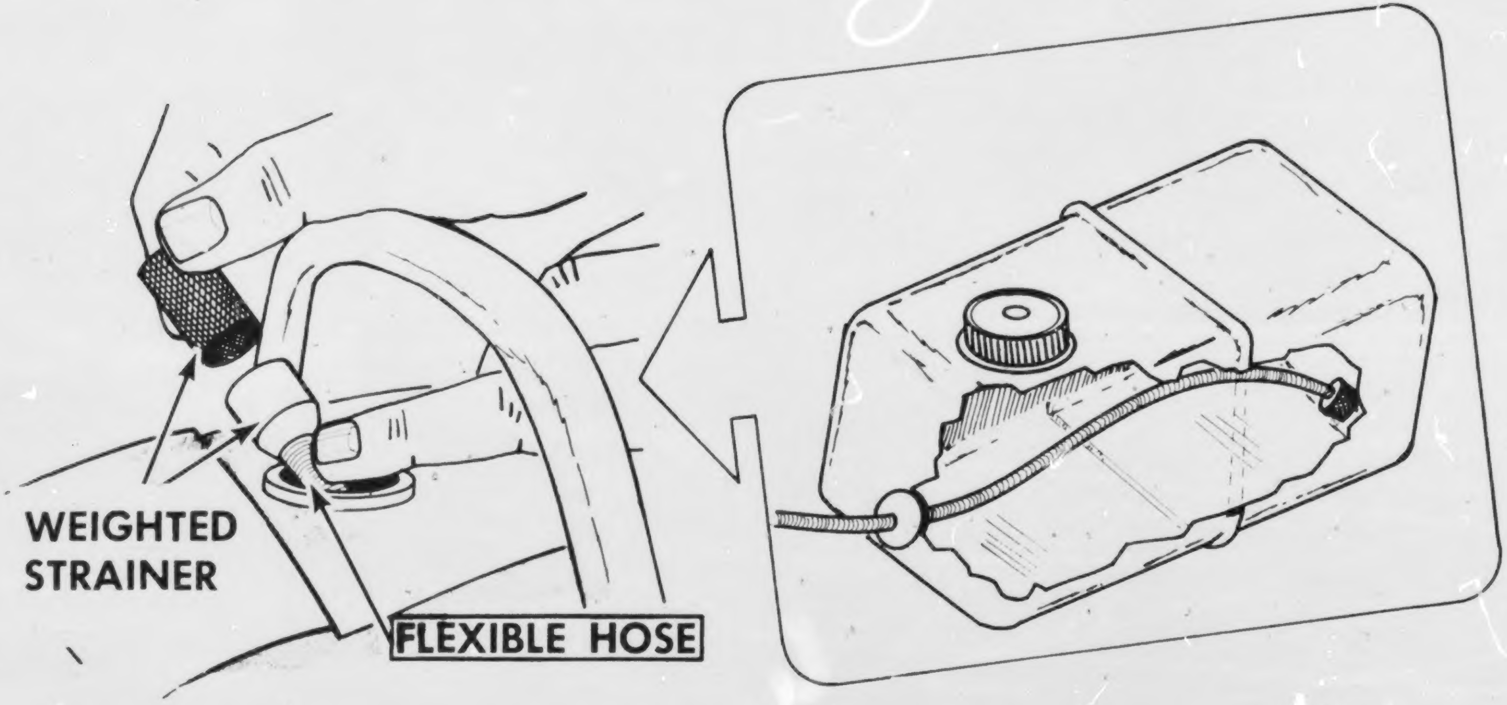
PUMP SYSTEM



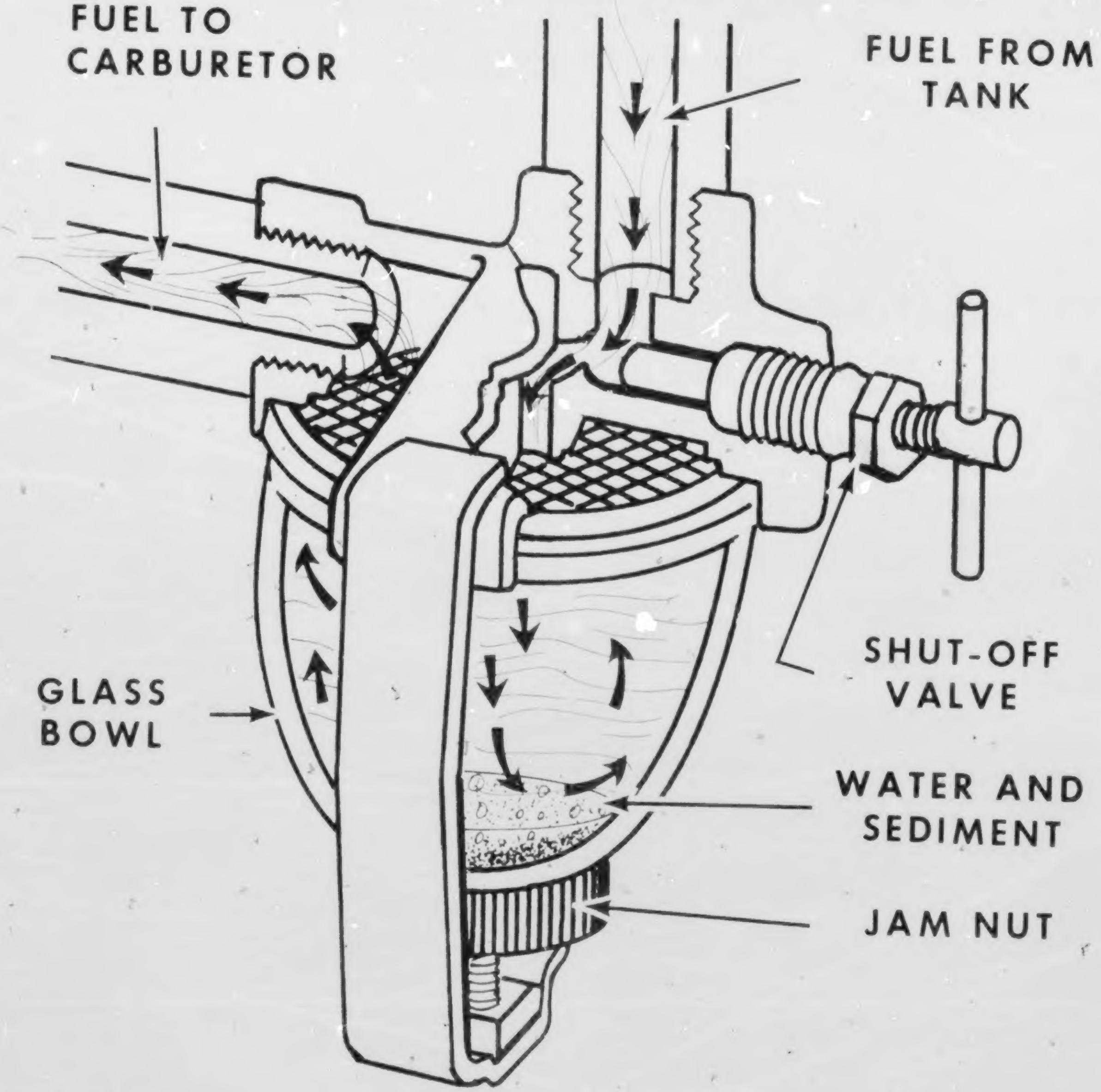
GRAVITY-FEED FUEL SYSTEM

FUEL FILTER

Filter attached to end of flexible fuel hose

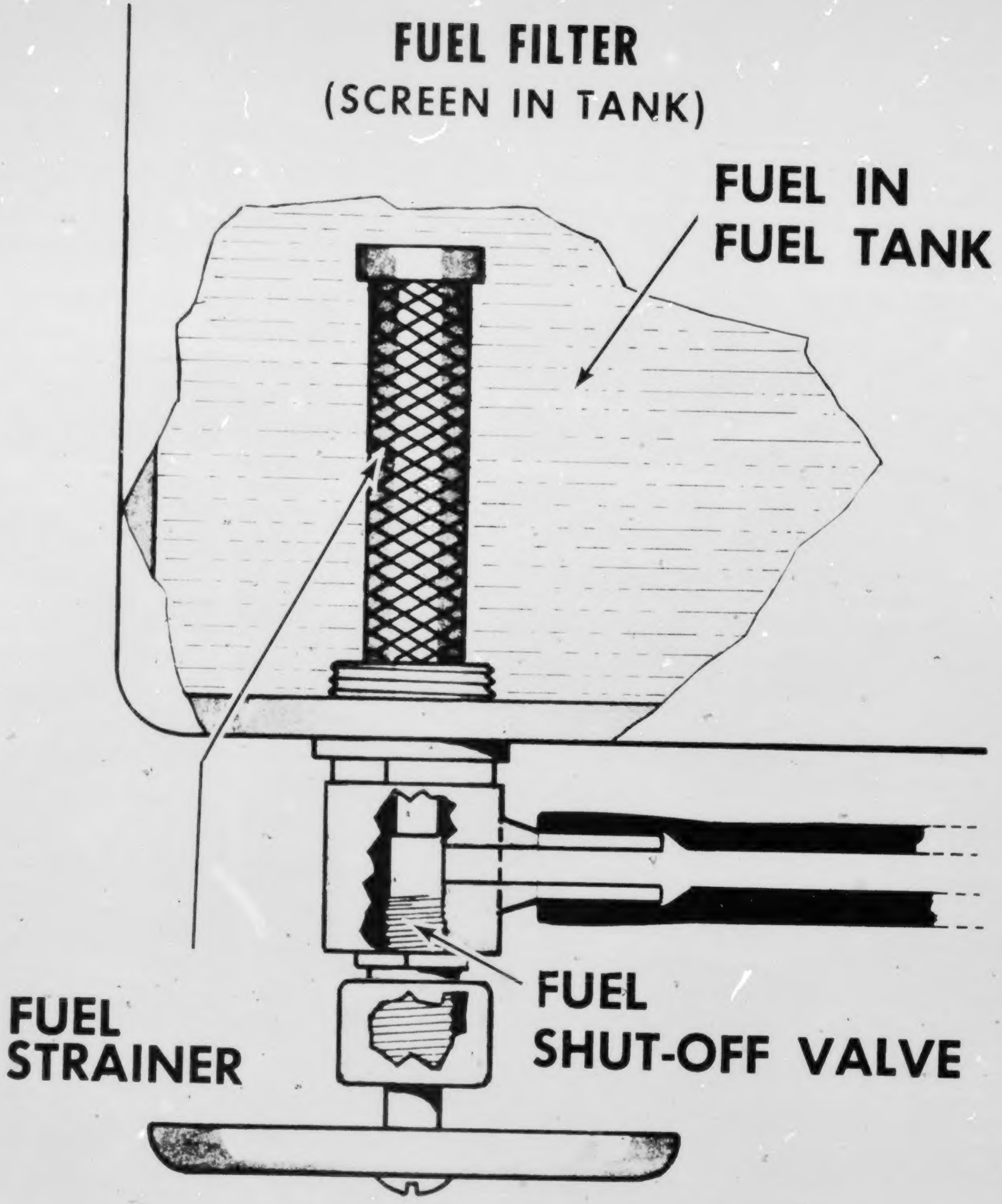

WEIGHTED STRAINER
FLEXIBLE HOSE

FUEL-FILTER
(GLASS SEDIMENT BOWL AND SCREEN)


FUEL TO CARBURETOR
FUEL FROM TANK
SHUT-OFF VALVE
GLASS BOWL
WATER AND SEDIMENT
JAM NUT

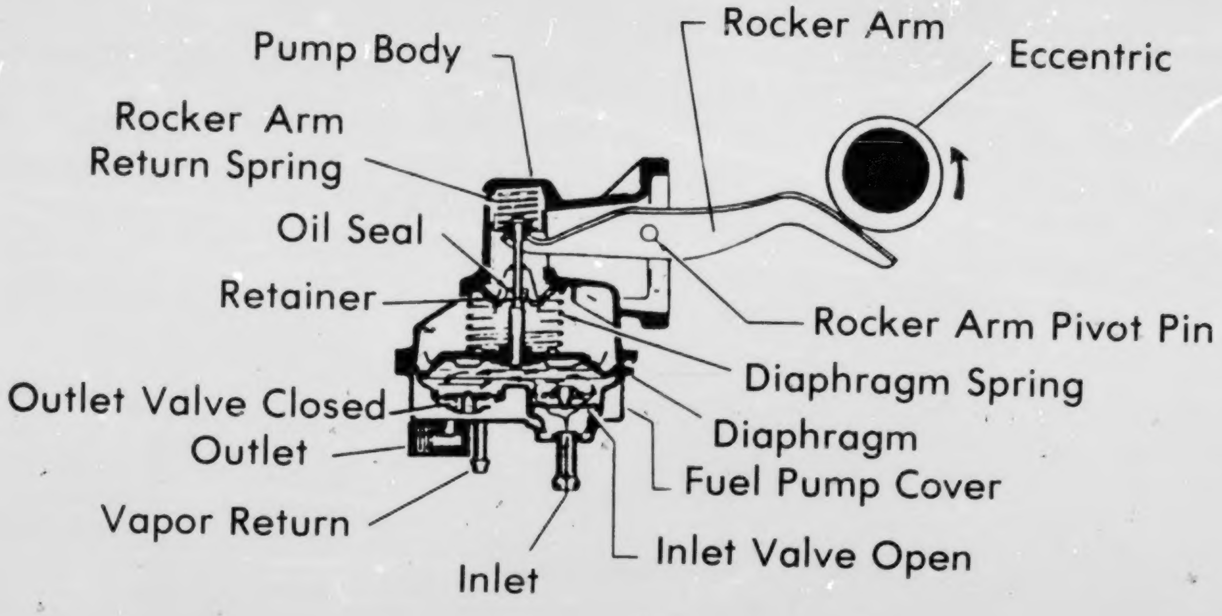
FUEL FILTER

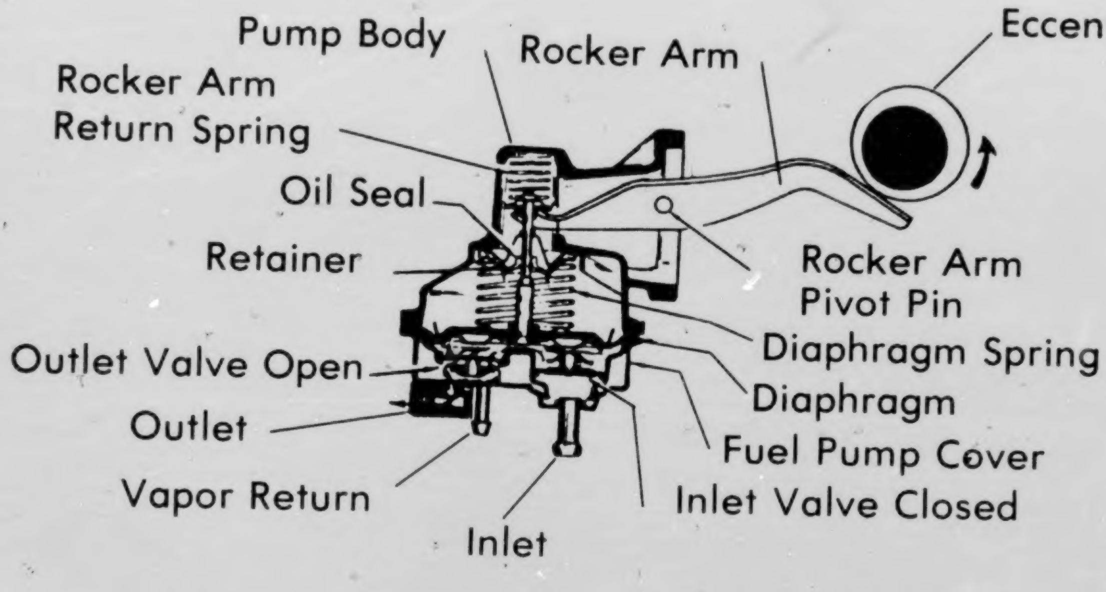
(SCREEN IN TANK)



FUEL IN
FUEL TANK
FUEL
STRAINER
FUEL
SHUT-OFF VALVE

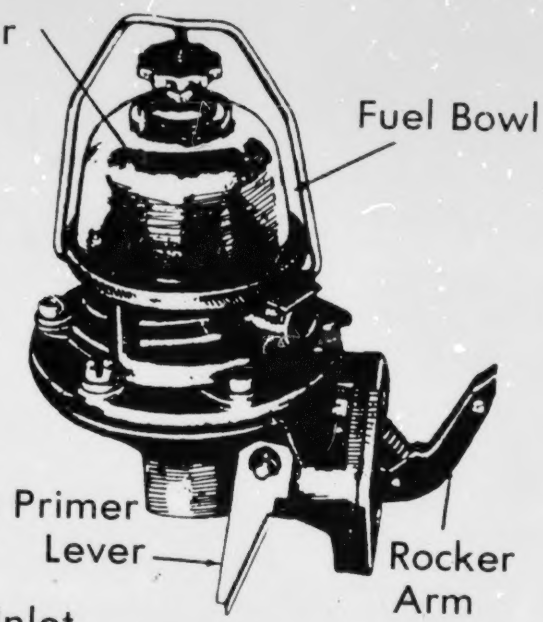
FUEL PUMP

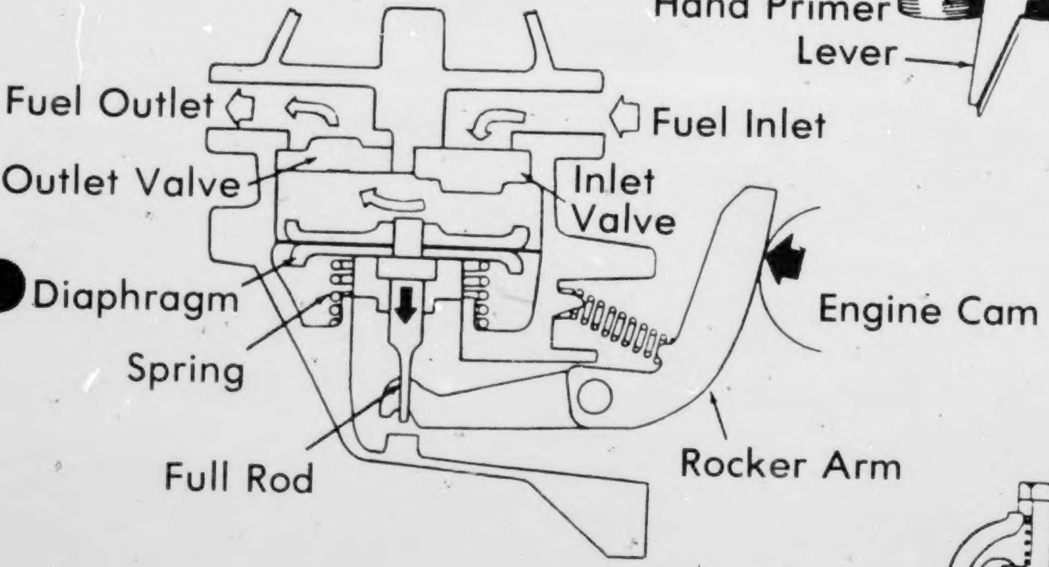

Pump Body
Rocker Arm
Eccentric
Rocker Arm Return Spring
Oil Seal
Retainer
Rocker Arm Pivot Pin
Diaphragm Spring
Outlet Valve Closed
Diaphragm
Outlet
Fuel Pump Cover
Vapor Return
Inlet Valve Open
Inlet

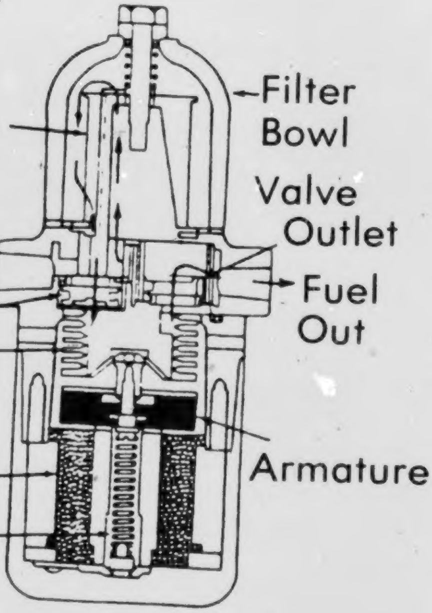

Pump Body
Rocker Arm
Eccentric
Rocker Arm Return Spring
Oil Seal
Retainer
Rocker Arm Pivot Pin
Diaphragm Spring
Outlet Valve Open
Diaphragm
Outlet
Fuel Pump Cover
Vapor Return
Inlet Valve Closed
Inlet

FUEL PUMP

OPERATION OF FUEL PUMP


Fuel Strainer
Fuel Bowl
Hand Primer Lever
Rocker Arm


Fuel Outlet
Fuel Inlet
Outlet Valve
Inlet Valve
Diaphragm
Engine Cam
Spring
Full Rod
Rocker Arm

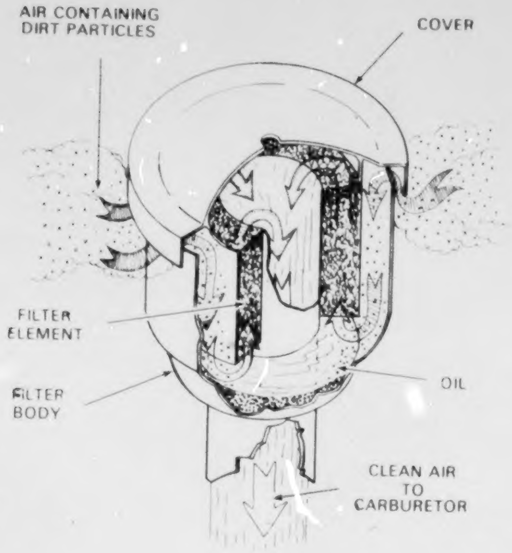

Filter Element
Filter Bowl
Valve Outlet
Fuel Out
Inlet Valve
Bellows
Armature
Electromagnet
Return Spring

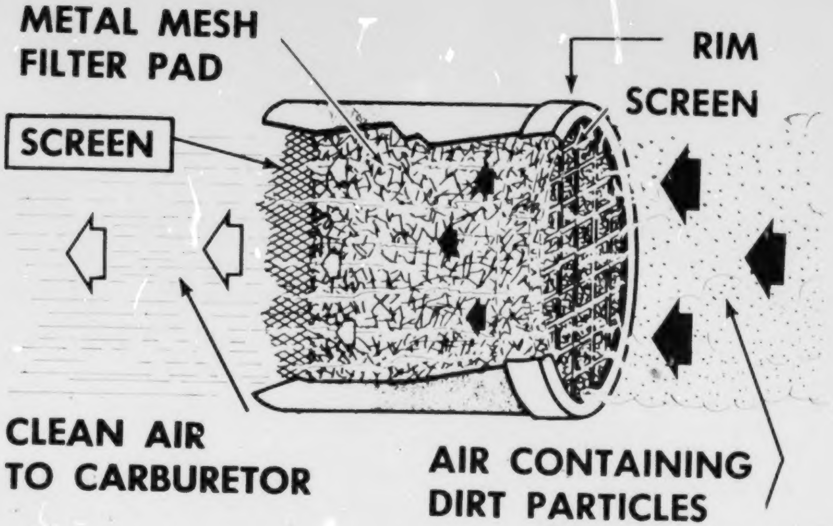
CUTAWAY VIEW OF ELECTRIC FUEL PUMP

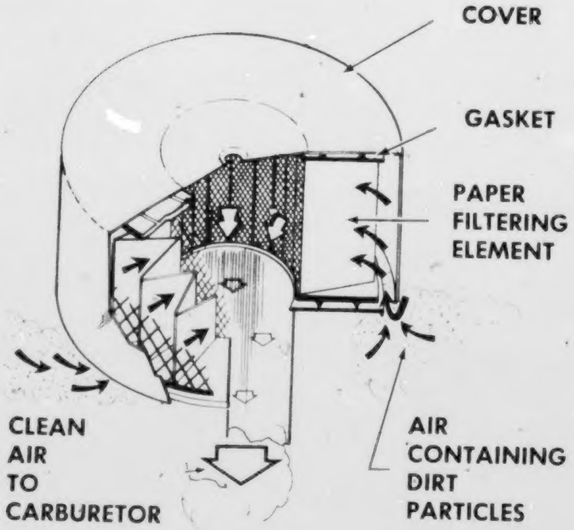
500

AIR CLEANERS

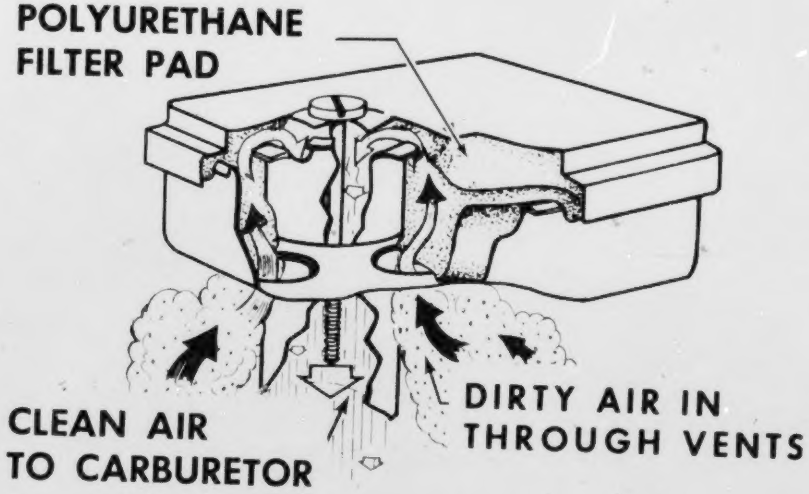
OIL-BATH AIR CLEANER


AIR CONTAINING DIRT PARTICLES
COVER
FILTER ELEMENT
FILTER BODY
OIL
CLEAN AIR TO CARBURETOR


METAL MESH FILTER PAD
RIM
SCREEN
SCREEN
CLEAN AIR TO CARBURETOR
AIR CONTAINING DIRT PARTICLES


COVER
GASKET
PAPER FILTERING ELEMENT
CLEAN AIR TO CARBURETOR
AIR CONTAINING DIRT PARTICLES

DRY-FILTER AIR CLEANER

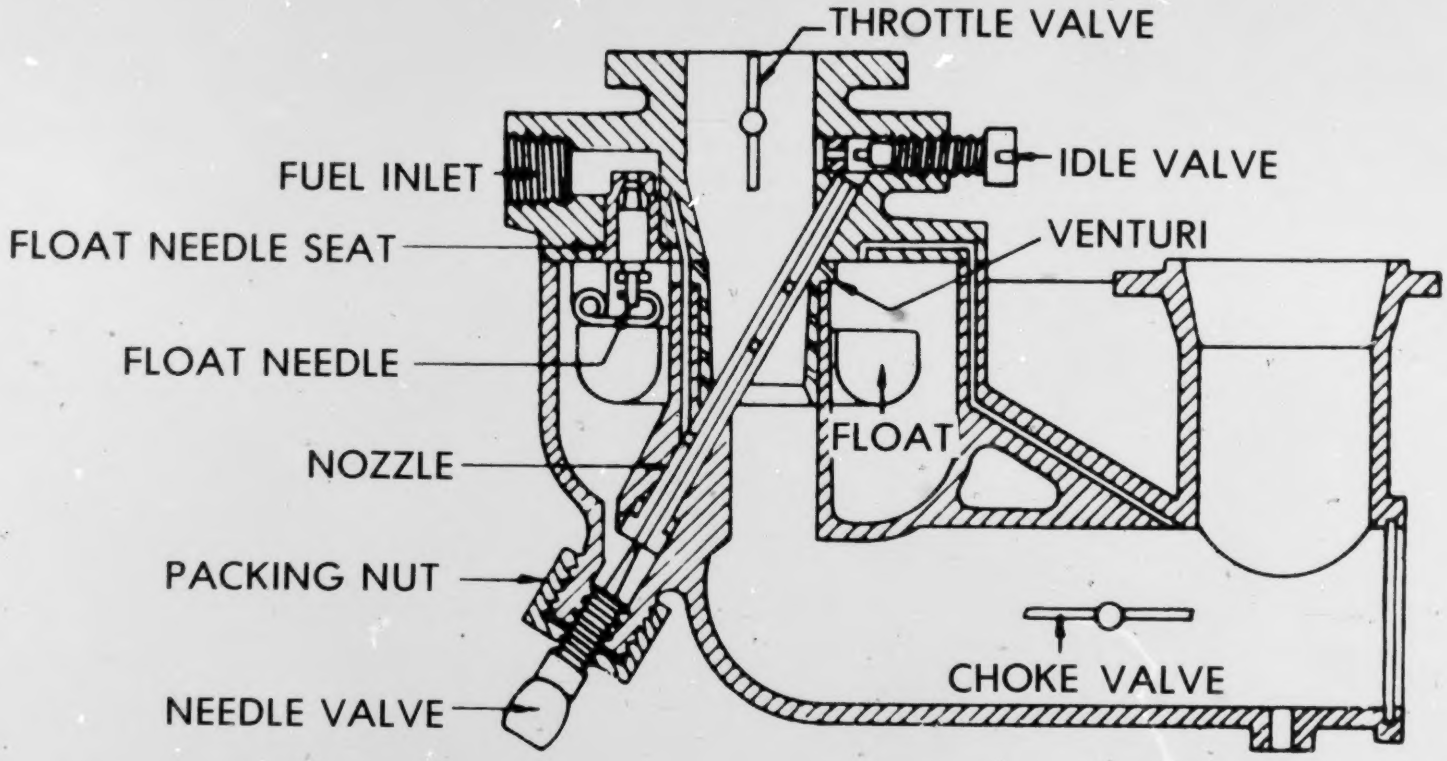

POLYURETHANE FILTER PAD
CLEAN AIR TO CARBURETOR
DIRTY AIR IN THROUGH VENTS

POLYURETHANE TYPE

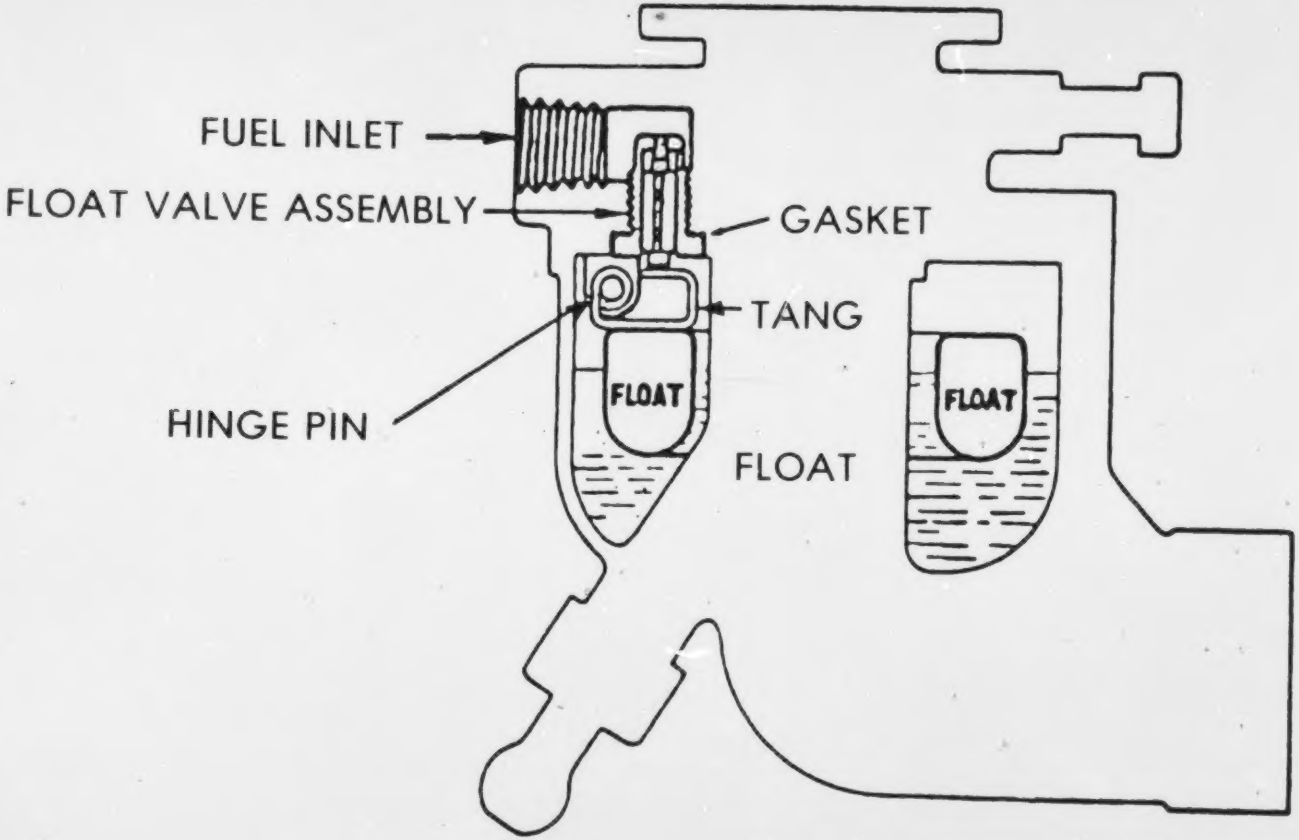
TM 7

SE - 107-D

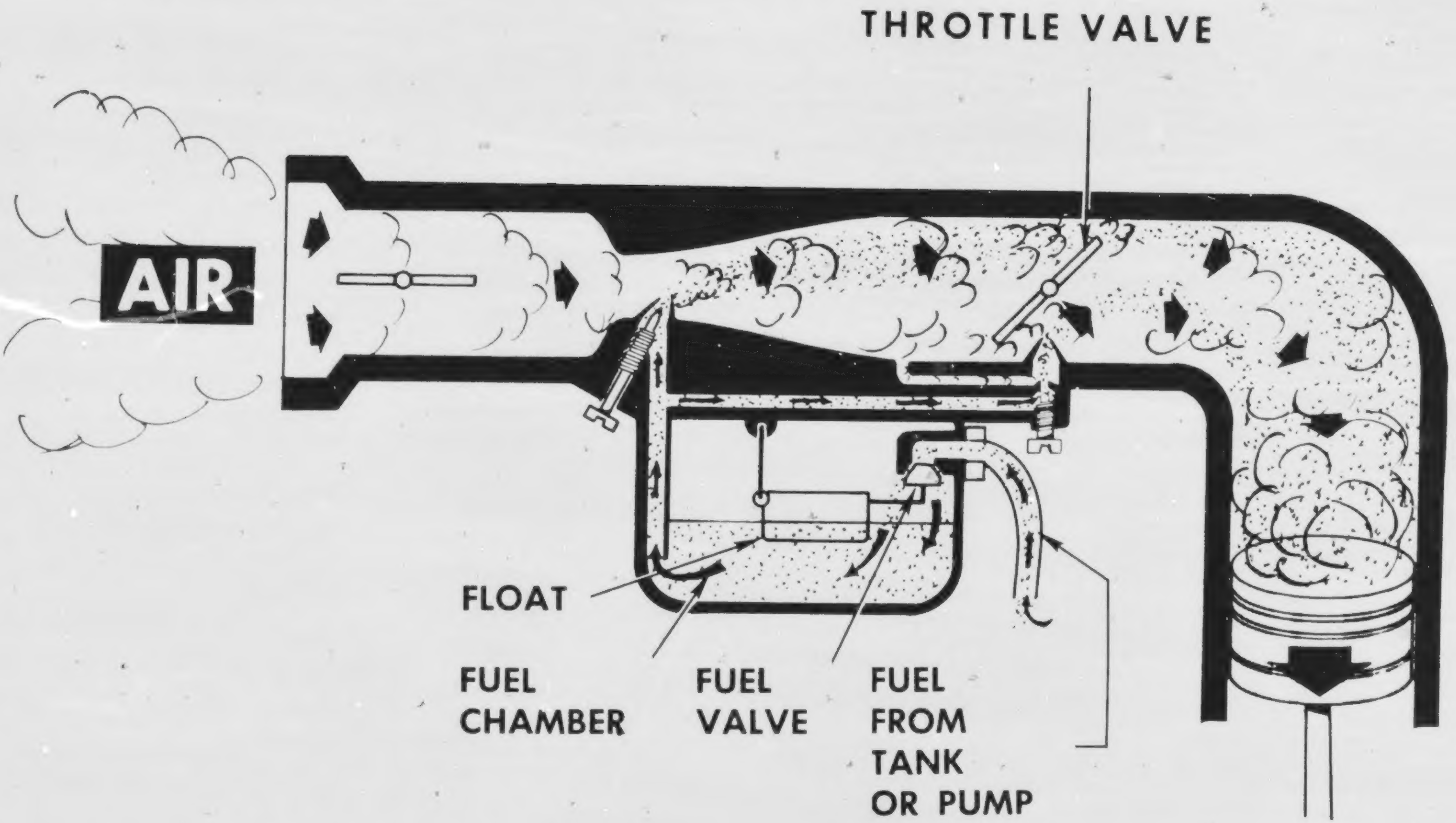
PARTS OF A FLOAT CARBURETOR


THROTTLE VALVE
FUEL INLET
IDLE VALVE
FLOAT NEEDLE SEAT
VENTURI
FLOAT NEEDLE
FLOAT
NOZZLE
PACKING NUT
CHOKE VALVE
NEEDLE VALVE

THE FLOAT SYSTEM

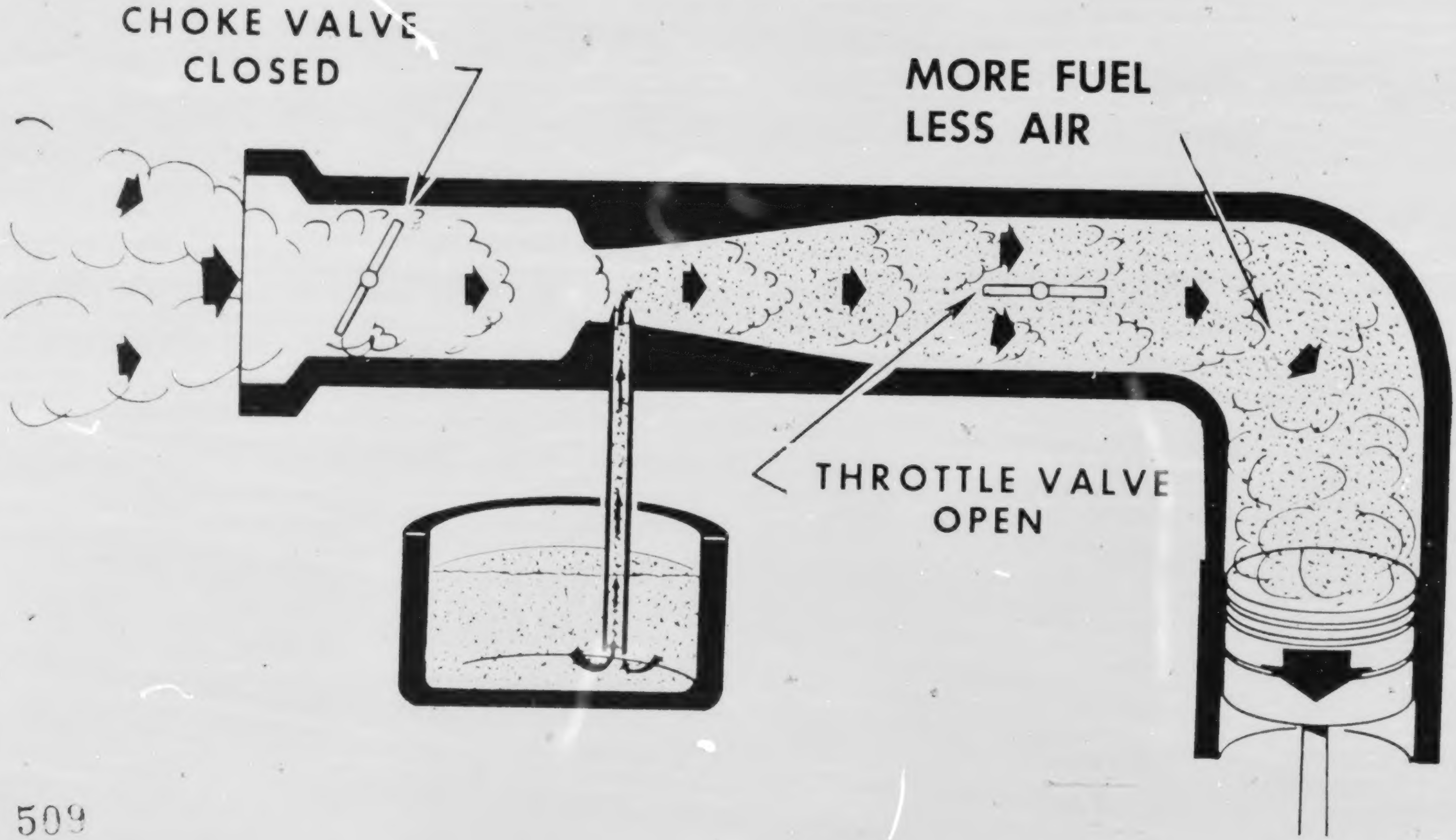

FUEL INLET
FLOAT VALVE ASSEMBLY
GASKET
TANG
HINGE PIN
FLOAT
FLOAT
FLOAT

FLOAT-TYPE CARBURETOR

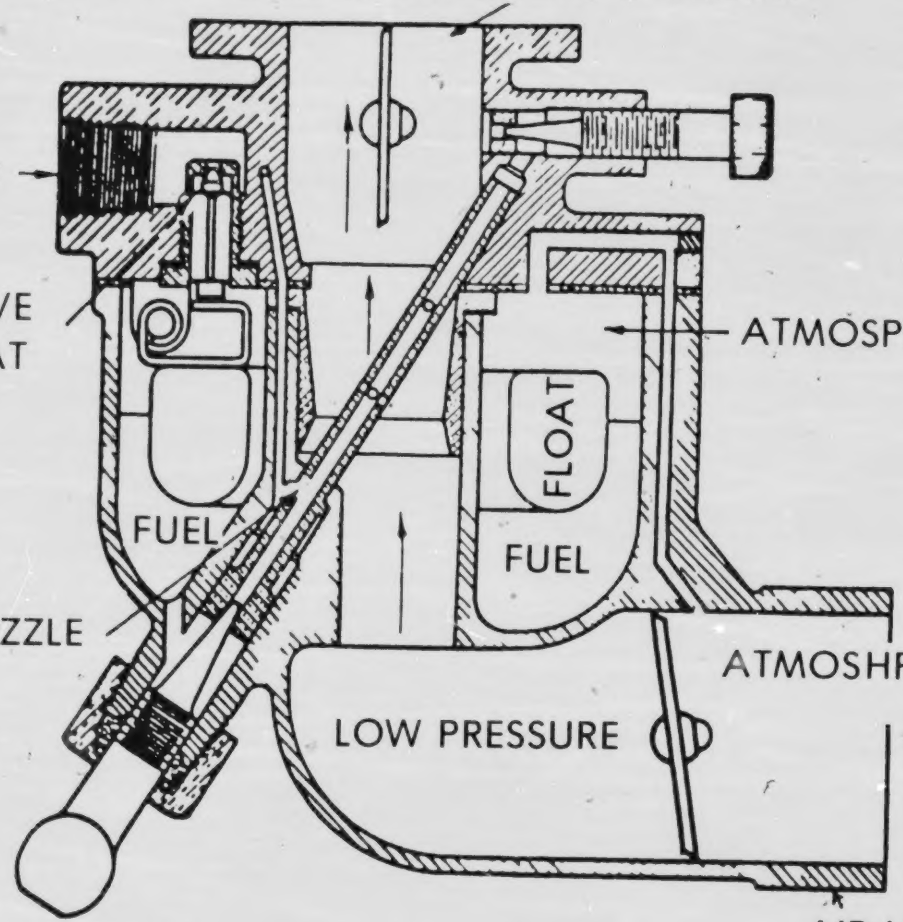

THROTTLE VALVE
AIR
FLOAT
FUEL CHAMBER
FUEL VALVE
FUEL FROM TANK OR PUMP

507

CARBURETOR CHOKE VALVE


CHOKE VALVE
CLOSED
MORE FUEL
LESS AIR
THROTTLE VALVE
OPEN

CHOKE SYSTEM


FLOAT
FUEL
FUEL
LOW PRESSURE

VERY LOW PRESSURE WHEN CHOKE IS CLOSED

FUEL INLET

FLOAT VALVE
AND SEAT

ATMOSPHERIC PRESSURE

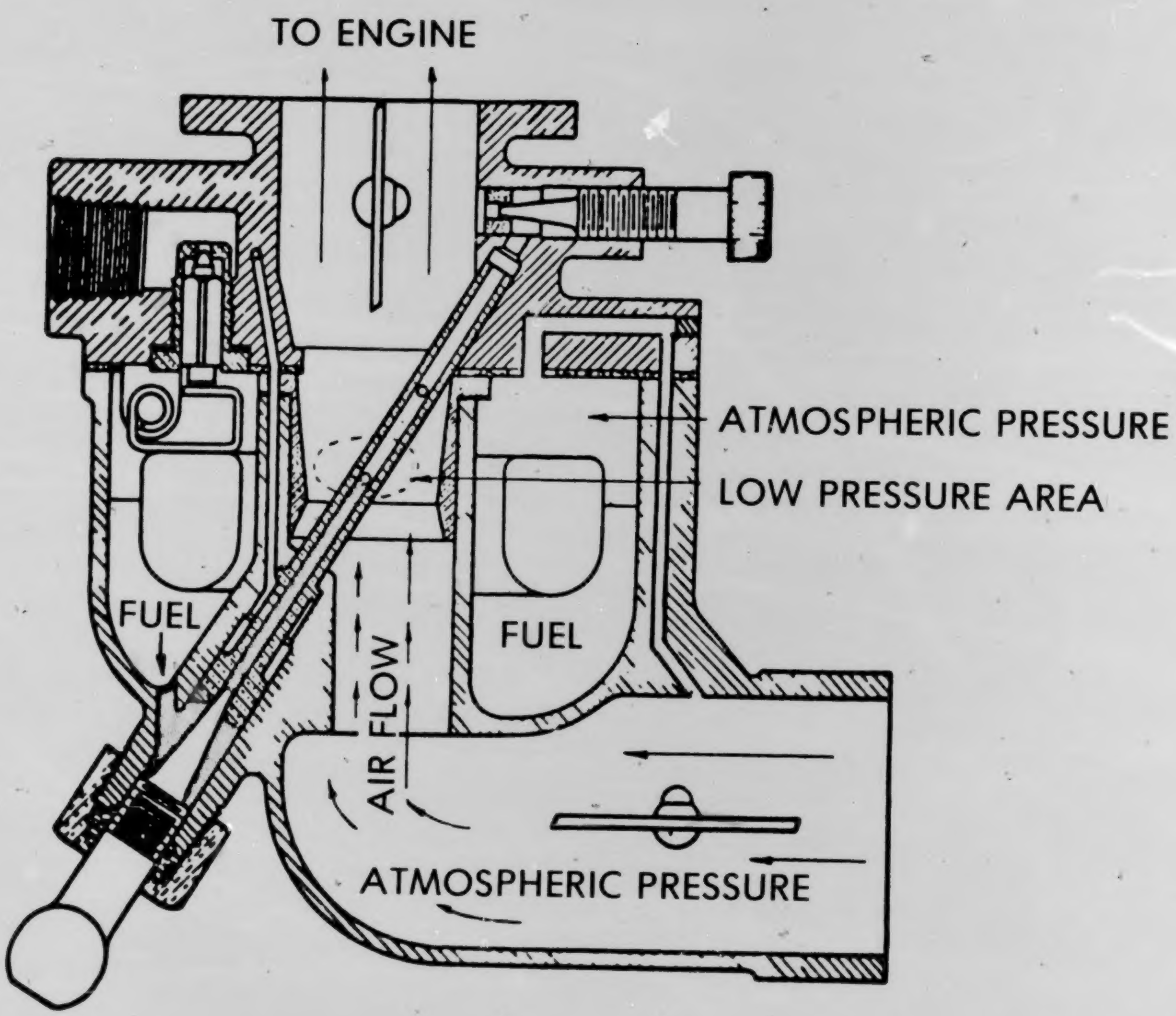
HIGHSPEED NOZZLE

ATMOSHPERIC PRESSURE

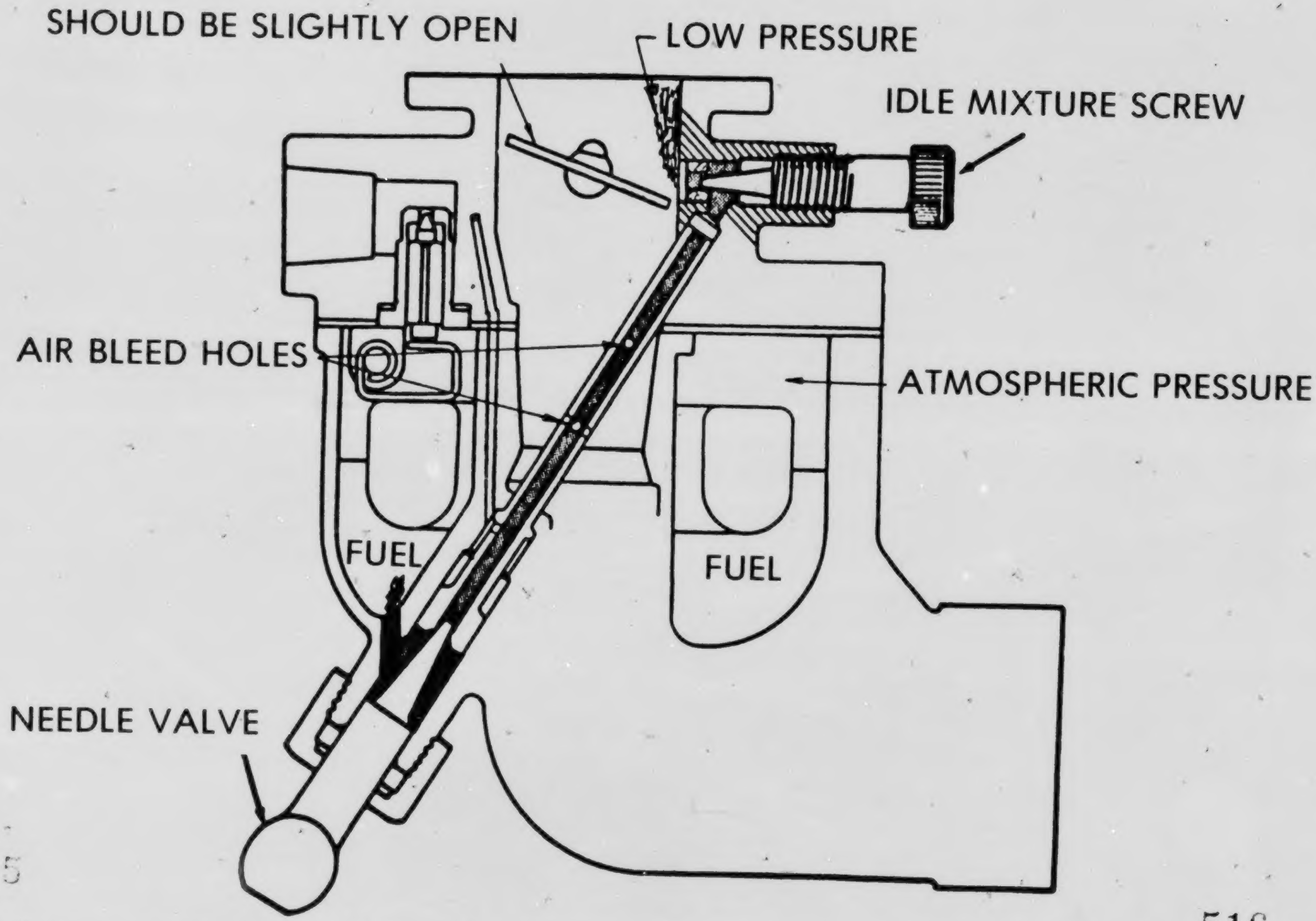
AIR HORN

CHOKE CLOSED

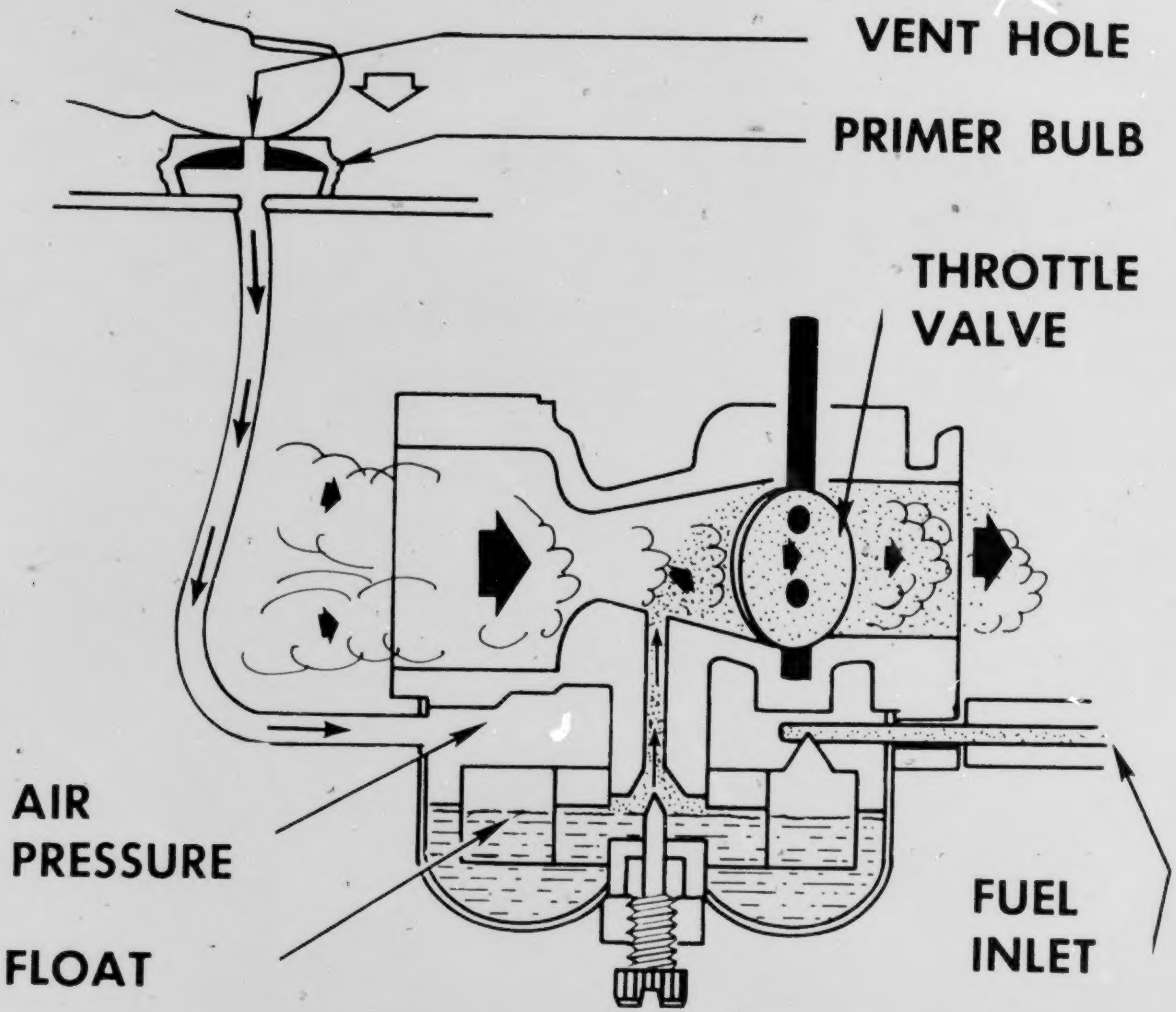
THE HIGH SPEED SYSTEM


TO ENGINE
ATMOSPHERIC PRESSURE
LOW PRESSURE AREA
FUEL
FUEL
AIR FLOW
ATMOSPHERIC PRESSURE

THE IDLE SYSTEM


SHOULD BE SLIGHTLY OPEN
LOW PRESSURE
IDLE MIXTURE SCREW
AIR BLEED HOLES
ATMOSPHERIC PRESSURE
FUEL
FUEL
NEEDLE VALVE

BULB TYPE PRIMER


VENT HOLE
PRIMER BULB
THROTTLE VALVE
AIR PRESSURE
FLOAT
FUEL INLET

TM 15

SE - 123-D

FUEL SYSTEMS
UNIT III

JOB SHEET #1--SERVICE AN AIR CLEANER

I. Tools and materials

   A. Compressed air

   B. Container of solvent and cleaning brush

   C. Shop towels

   D. Screwdriver

   E. Clean engine oil

   F. Safety glasses

II. Procedure

   A. Disconnect and ground spark plug wire

   B. Remove air cleaner fasteners

   C. Remove air cleaner and air cleaner cover

   D. Determine the type of air cleaner element

   E. Service air cleaner according to type

      1. Service paper air cleaner element

         (NOTE: Paper air cleaner elements should be replaced at specified intervals.)

         a. Clean by tapping lightly on a flat surface or by directing a controlled stream of compressed air through the element opposite normal air flow (Figure 1)

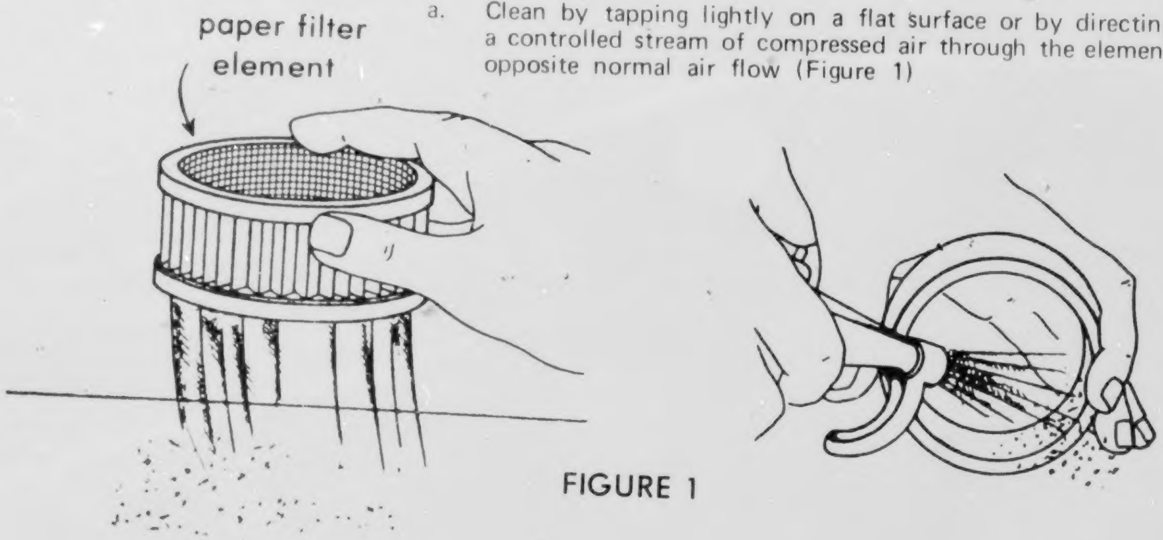


FIGURE 1

JOB SHEET #1

b. Before reinstalling, check the element against the light to make sure there are not holes or ruptures present

(NOTE: Light should be visible. If not, discard element.)

c. Check bottom and top gasket surfaces of the paper element for damage

d. Install right side up when indicated

2. Service polyurethane element

a. Remove the polyurethane element from the support screen

b. Wash it thoroughly (Figure 2)

(NOTE: The element can be washed in solvent or soap and water.)

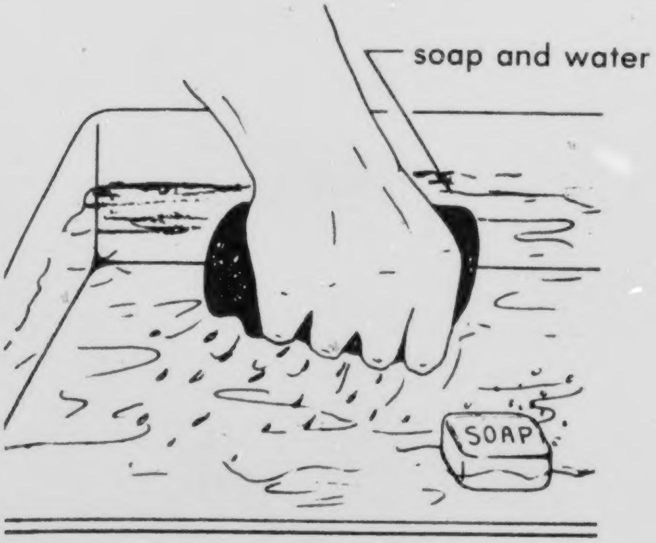


FIGURE 2

c. Squeeze out the solvent or soap and water

(NOTE: Do not wring, as the element might tear.)

d. Reoil the filter element with clean engine oil

JOB SHEET #1

e. Squeeze the excess oil from the filter element (Figure 3)

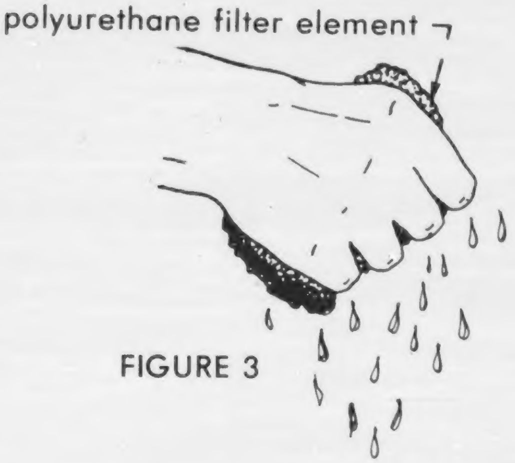

polyurethane filter element

FIGURE 3

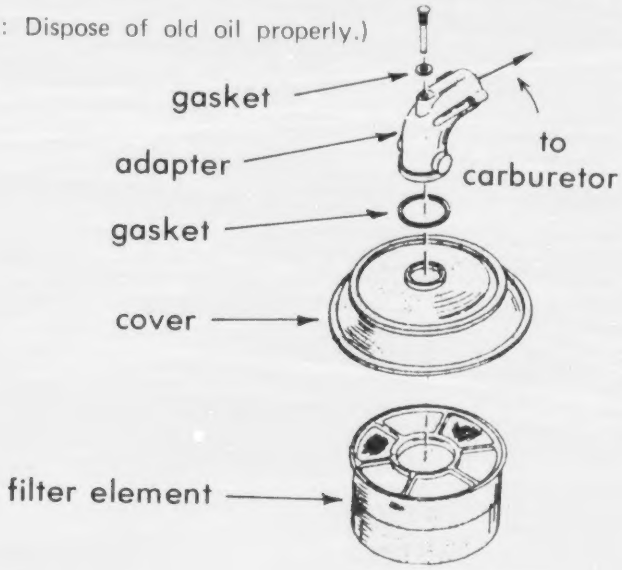
f. Replace element on support screen

(NOTE: Make sure the element is placed on the support screen to form a sound seal for both top and bottom contact edges.)

3. Service oil bath air cleaner

a. Remove wing nut and separate parts for cleaning (Figure 4)

(NOTE: Dispose of old oil properly.)


gasket
adapter
gasket
cover
filter element
to carburetor

JOB SHEET #1

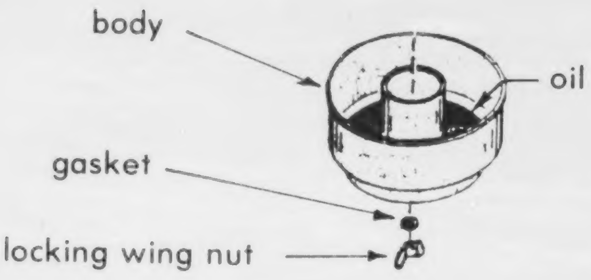


FIGURE 4

b. Rinse air strainer and parts in clean solvent (Figure 5)

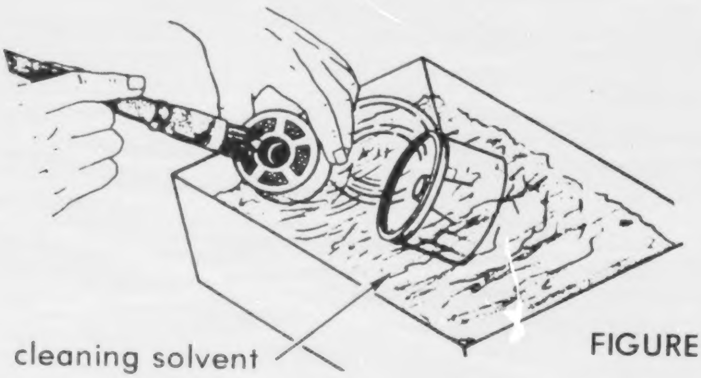


FIGURE 5

c. Shake excessive solvent out of the air strainer

(CAUTION: Wear eye protection, as the solvent is harmful to the eyes.)

d. Saturate the air strainer gauze with light oil and allow excess to drip off

e. Wash dirt and grit out of lower cup with clean solvent

f. Fill lower cup to correct level with fresh engine oil of correct type for engine

g. Place units together and install wing nut

(NOTE: Make sure gasket is in place between the air strainer and lower cup.)

h. Tighten wing nut securely

JOB SHEET #1

F. Clean the filter body and cover before replacing

G. Make certain the air cleaner to carburetor gasket is in good condition and in place; replace if necessary

H. Replace the air cleaner body

(NOTE: Make sure the air cleaner faces in the correct direction. If a locating tang or lug is present, make sure it engages properly.)

I. Tighten the air cleaner wing nut or bolt securely

(NOTE: Avoid overtightening as this can cause carburetor warpage or improper operation of the choke.)

J. Install any hoses to air cleaner as required

FUEL SYSTEMS
UNIT III

JOB SHEET #2--REMOVE AND REPLACE A CARBURETOR

I. Tools and materials

A. Hand tool assortment

B. Tubing wrenches

C. Torque wrench

D. Safety glasses

II. Procedure

A. Disconnect and ground spark plug wire

B. Remove the air cleaner

C. Disconnect the fuel line

(NOTE: Use a backup wrench to avoid twisting the fuel line. Use a container to catch gas drippings.)

D. Disconnect the throttle linkage

E. Disconnect the choke control cable if one is used

F. Remove the ignition ground wire if one is used

G. Remove the nuts or bolts that hold the carburetor

H. Remove the carburetor

(NOTE: Some throttle linkages can only be removed at this time; be careful not to bend them and identify their correct mounting location.)

I. Remove the old carburetor to manifold gasket

J. Clean the gasket mounting surface

(NOTE: Plug the manifold opening to prevent foreign material from entering engine.)

K. Install the new manifold to carburetor gasket

JOB SHEET #2

L. Place the carburetor in the correct position and start fasteners

(NOTE: Some carburetors need to have the throttle linkage connected at this time; mount the linkage in correct locations.)

M. Tighten and torque carburetor fasteners

N. Replace throttle linkage if not connected before

O. Connect the choke linkage

P. Connect the ignition ground wire in the correct position

Q. Connect the fuel line to the carburetor

(NOTE: Use caution to avoid cross threading.)

R. Tighten the fuel line securely

(NOTE: Use a backup wrench to avoid fuel line twisting.)

S. Check to make sure all connections and accessories are secure

T. Start the engine and check for leaks

(CAUTION: A loose connection or unsecured fuel line can come loose, break, or leak. If this happens, fuel will leak and if ignited this fuel will cause a dangerous fire. Be correct in your work.)

U. Make idle air mixture and idle speed adjustments as required by engine manual

FUEL SYSTEM
UNIT III

JOB SHEET #3--SERVICE FLOAT TYPE CARBURETOR

I. Tools and materials

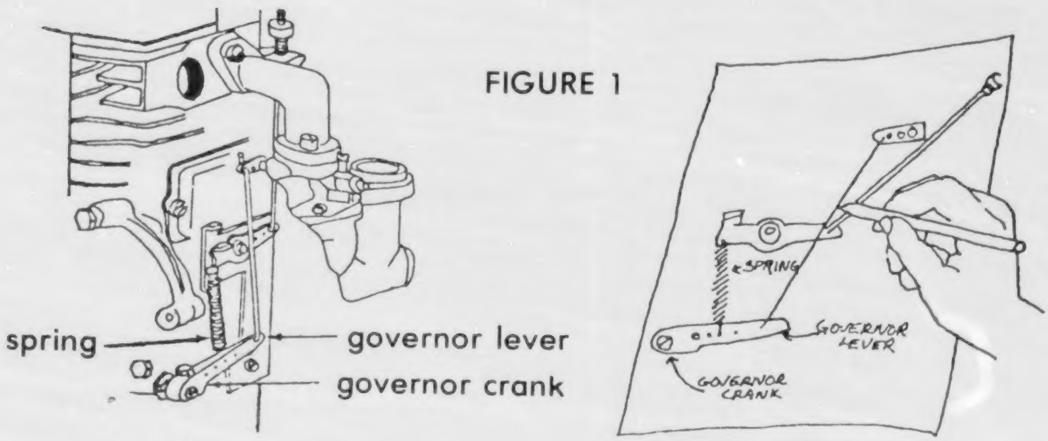
- A. Hand tool assortment
- B. Suitable carburetor cleaning fluid
- C. Parts cleaning basket
- D. Safety glasses

II. Procedure

- A. Disconnect and ground spark plug wire
- B. Close fuel shut-off valve
- C. Disconnect fuel line
- D. Disconnect throttle and choke cable
- E. Disconnect governor linkage

(NOTE: It is recommended that you make a sketch of the linkages and their positions to aid reassembly. See Figure 1.)

FIGURE 1


spring
governor lever
governor crank
SPRING
GOVERNOR LEVER
GOVERNOR CRANK

JOB SHEET #3

F. Remove the carburetor

(NOTE: Some models have a breather return hose to disconnect. See Figure 2.)

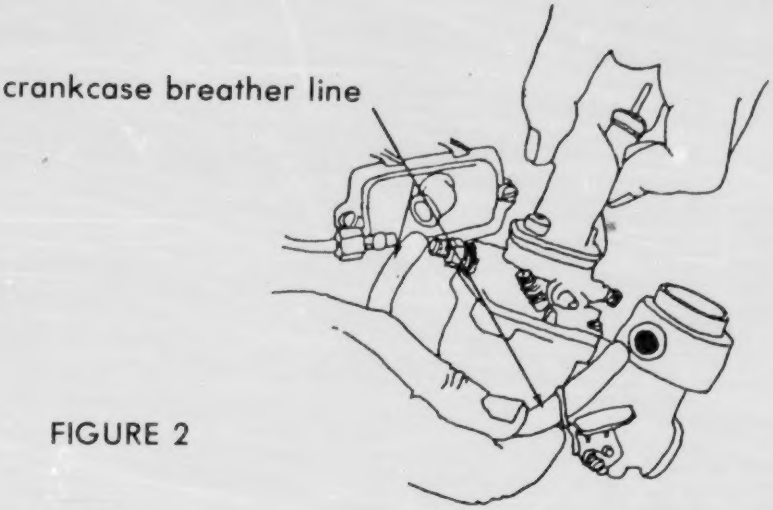

crankcase breather line

FIGURE 2

G. Remove the intake valve plate from the carburetor on some two-cycle engines (Figure 3)

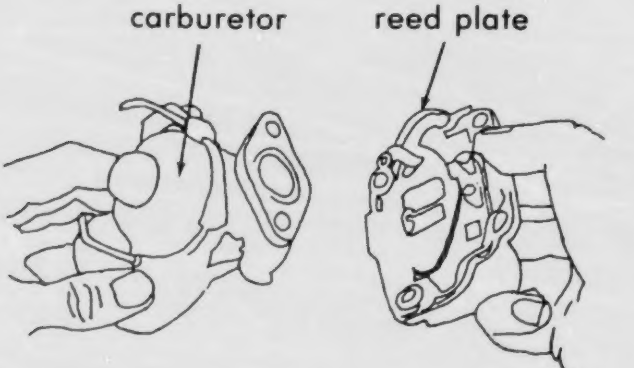

carburetor
reed plate

FIGURE 3

JOB SHEET #3

H. Check throttle shaft bushing for wear (Figure 4)

(NOTE: Check engine manufacturer's specifications.)

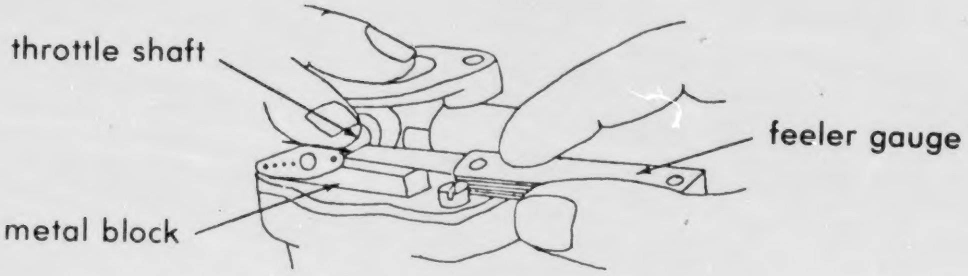

throttle shaft
feeler gauge
metal block

FIGURE 4

I. Remove and check the condition of the high speed and idle speed needle valves (Figure 5)

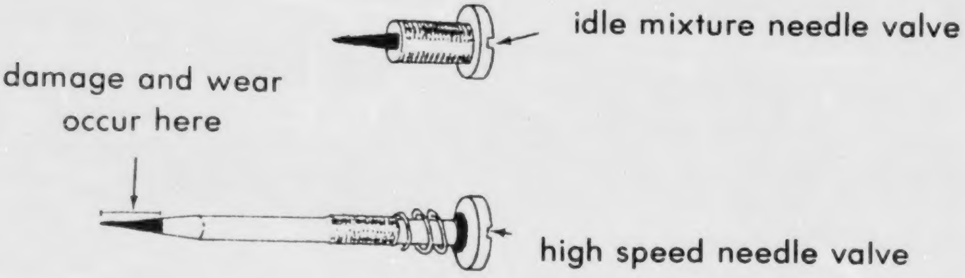

idle mixture needle valve
damage and wear occur here
high speed needle valve

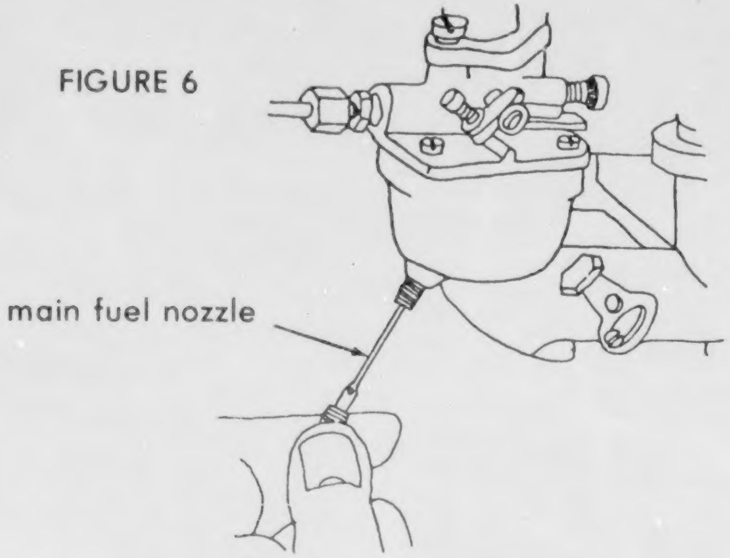
FIGURE 5

JOB SHEET #3

J. Remove the float bowl

(NOTE: On two piece carburetors remove the main fuel nozzle before removing float bowl. See Figure 6.)

FIGURE 6


main fuel nozzle

K. Remove float hinge pin and remove float

L. Remove float valve and inspect for wear; replace if a groove is worn in the tapered point of the valve (Figure 7)

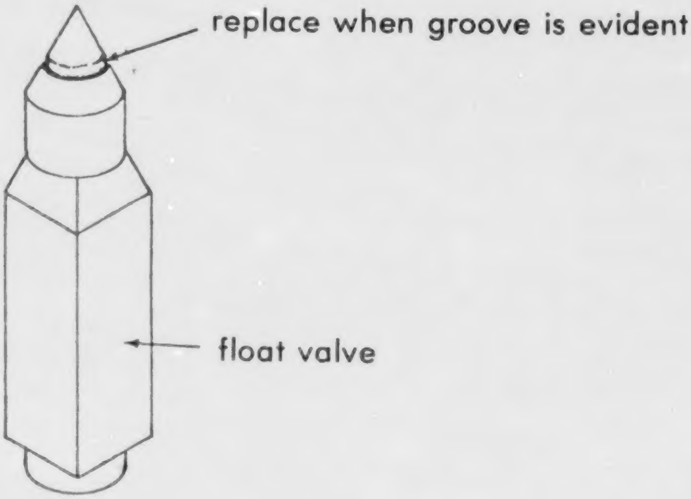

replace when groove is evident
float valve

FIGURE 7

JOB SHEET #3

M. Inspect the floats for

1. Worn hinges

2. Fuel in metal floats; replace if you feel a liquid inside the float

3. Good varnish coating on cork floats; replace the float if the varnish is pealing or has been punched (Figure 8)

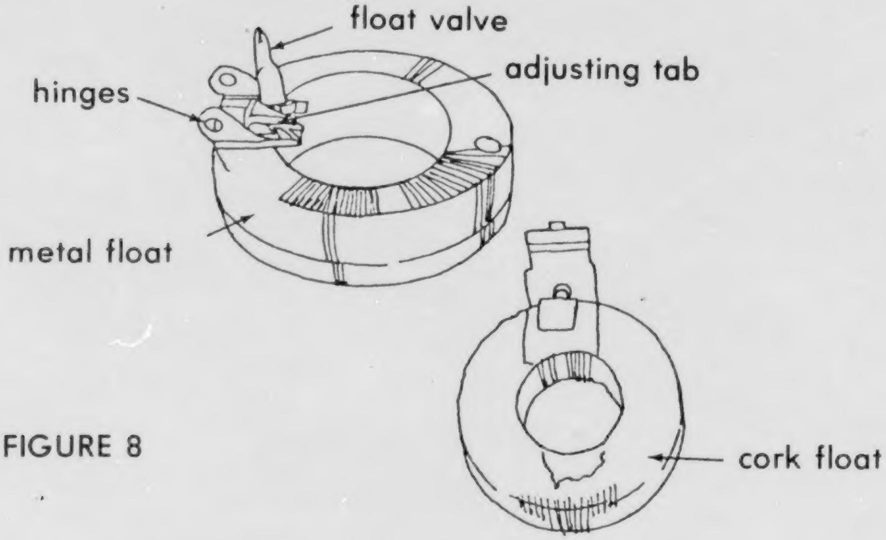


FIGURE 8

N. Remove all gaskets and/or rubber parts on the carburetor

O. Place all the carburetor parts except the gaskets, float, and rubber parts in a cleaner basket

P. Place the basket in the carburetor cleaner and gently move it up and down to circulate the cleaner through the parts; then let it set for no more than thirty minutes

Q. Remove the basket from the cleaner

R. Rinse the parts and basket thoroughly with water

S. Dry the parts, one at a time, with compressed air

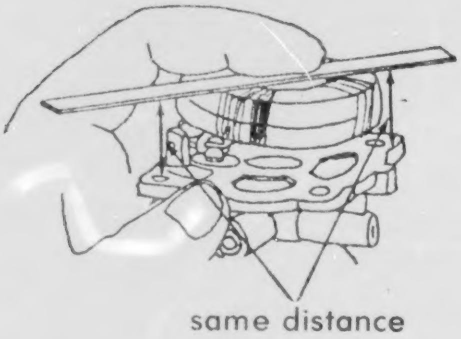
(NOTE: Be sure to blow out all passages in the carburetor body.)

T. Replace float valve and float in the carburetor body

JOB SHEET #3

U. Adjust the float level by bending the tab and measuring correct height with a steel ruler (Figure 9)

FIGURE 9


same distance

V. Check distance from carburetor to float top for proper height and equal distance on horizontal float (Figure 10)

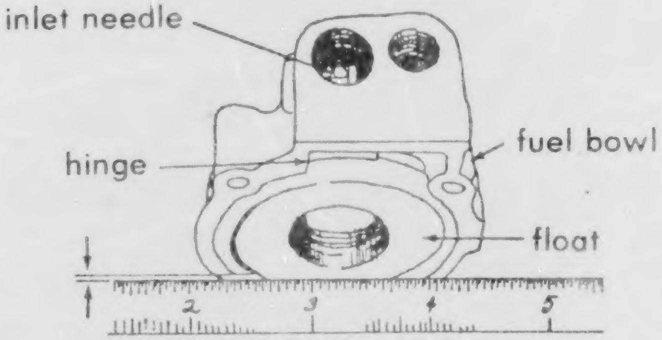

inlet needle
hinge
fuel bowl
float
2
3
4
5

FIGURE 10

JOB SHEET #3

W. Check distance on a vertical float from carburetor top to top of float

(NOTE: Float should be true vertical to the carburetor top to prevent interference with float bowl walls. See Figure 11.)

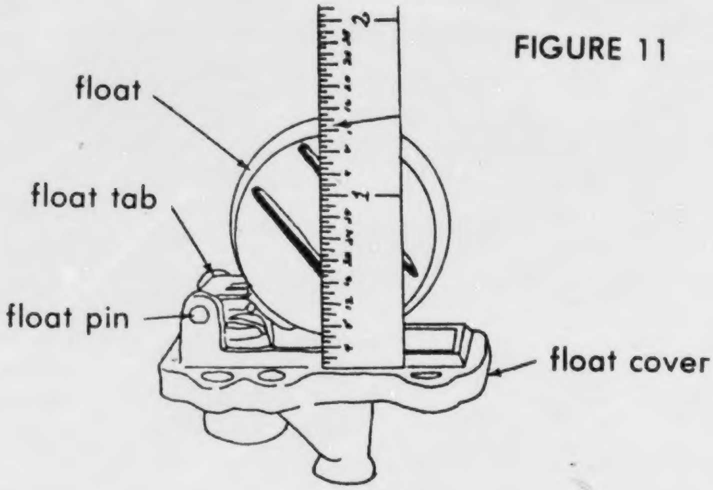


FIGURE 11

X. Check bottom of float for proper clearance in relation to float bowl

Y. Install new float bowl gasket and attach bowl to carburetor top

Z. Install idle mixture valve and screw it down until it is lightly seated; then back it out approximately two turns

(NOTE: Install the main fuel nozzle on the two-piece carburetor.)

AA. Install the high speed valve and screw it down until it is lightly seated; then back it out approximately two turns

(NOTE: Steps Y and Z are preliminary adjustments only and will be completed with the engine running.)

BB. Check for free operation of the throttle and choke valve

CC. Install the carburetor on the engine

DD. Reconnect the governor linkage according to the diagram sketched earlie

JOB SHEET #3

EE. Reconnect throttle and choke linkage

FF. Reconnect fuel line

GG. Open fuel shut-off valve and watch float bowl area of the carburetor for fuel leaks

(NOTE: Occasionally the float valve will get contamination in it that will keep it from shutting off. In this case, a few light taps on the valve area may release the contamination and solve the problem.)

HH. Start the engine and operate until it is at normal operating temperature

II. Adjust idle speed

JJ. Adjust the idle mixture valve to the highest and smoothest rpm at idle speed

(NOTE: It may be necessary to reset the idle speed again.)

KK. Accelerate the engine up to governor controlled rpm and adjust high speed valve to highest and smoothest rpm

FUEL SYSTEMS
UNIT III

JOB SHEET #4--REMOVE AND REPLACE A FUEL PUMP

I. Tools and materials

   A. Hand tool assortment

   B. Torque wrench

   C. Shop towels

   D. Gasket sealer

   E. Safety glasses

II. Procedure

   A. Disconnect and ground spark plug wire

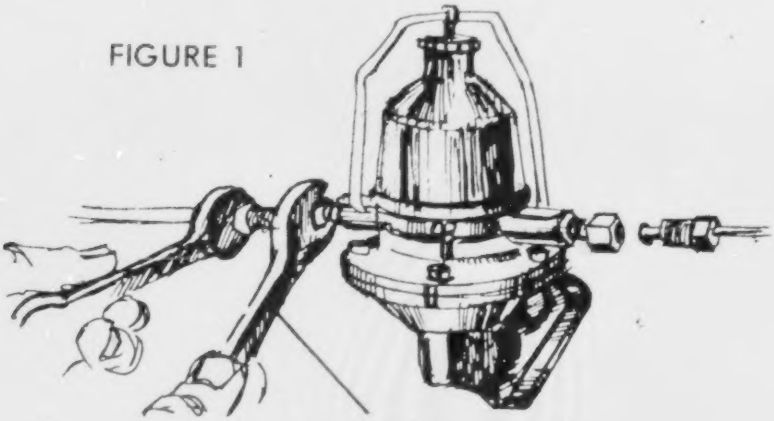
   B. Shut off fuel at tank

   C. Disconnect fuel lines from fuel pump

   (NOTE: Use a backup wrench and a tubing wrench if available to avoid twisting the line. See Figure 1.)

   (CAUTION: Do not allow fuel to drop as this will cause a danger of fire.)

FIGURE 1



JOB SHEET #4

D. Remove fuel pump

(NOTE: Check location of fuel pump arm so it can be returned to same location.)

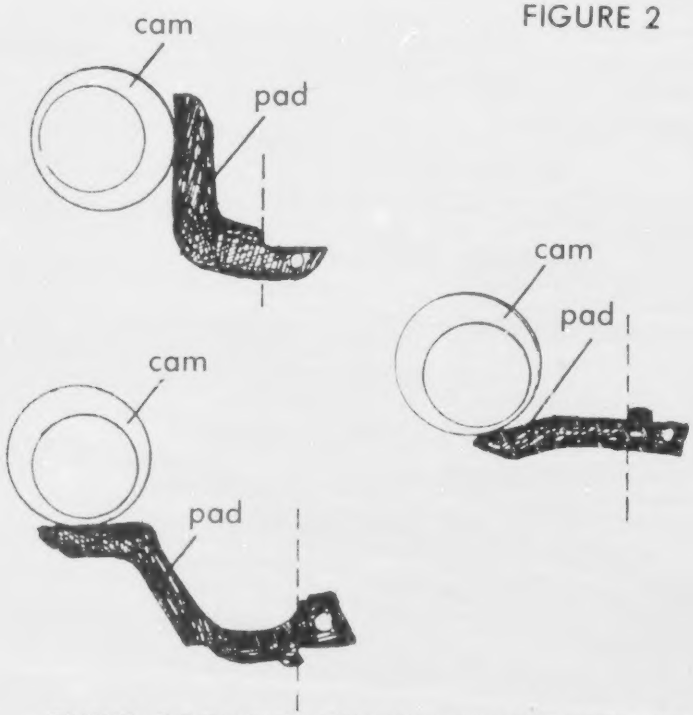
E. Clean fuel pump mounting surface on engine

F. Coat the mounting surfaces of the fuel pump and engine with gasket sealer

G. Install a new mounting gasket on the pump

H. Install pump with arm in same location as when pump was removed (Figure 2)

FIGURE 2



TYPES OF PAD TO CAM ARRANGEMENTS

JOB SHEET #4

I. Push pump inward until the mounting flange is against the mounting pad (Figure 3)

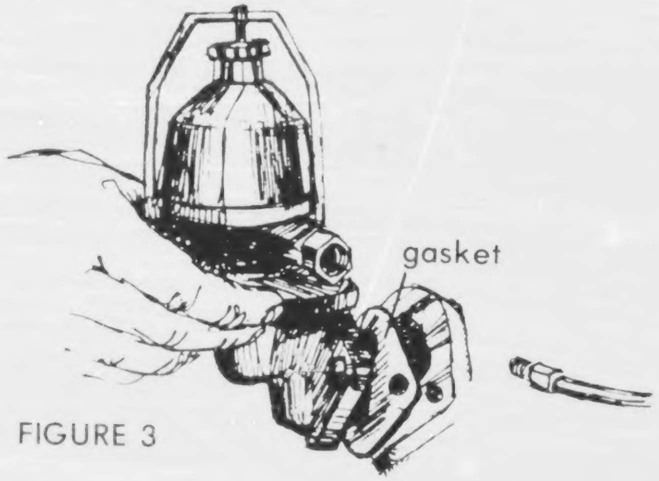


FIGURE 3

J. Install fasteners and torque to specifications

(NOTE: Do not force pump by using force of fasteners to pull it in.)

K. Attach the fuel lines

(NOTE: Be sure threads are in alignment and finger start to prevent cross threading.)

L. Tighten fuel lines securely

(NOTE: Use two wrenches to prevent damage to fuel lines and fittings.)

M. Turn on fuel at tank

N. Start engine and check for leaks; if a leak appears, stop engine immediately and repair

O. Clean up work area and return all tools

P. Have instructor inspect your work

FUEL SYSTEMS
UNIT III

JOB SHEET #5--TEST AND SERVICE A FUEL PUMP

I. Tools and materials

  A. Hand tool assortment

  B. Container to catch fuel in

  C. Shop towels

  D. Safety glasses

II. Procedure

  A. Disconnect and ground spark plug wire

  B. Disconnect fuel line at carburetor

  (NOTE: Use two tubing wrenches to prevent damaging fittings and fuel lines.)

  C. Hold a small container under the fuel line to catch fuel

  D. Crank the engine

  E. Fuel should flow out strongly and in regular squirts

  (NOTE: If fuel flow is weak or erratic, check the fuel lines or fuel filter. If clear, the fuel pump should be replaced.)

  F. Remove pump from engine

  (NOTE: Most fuel pumps are serviced by complete replacement.)

JOB SHEET #5

G. Using the correct repair kit and following manufacturer's repair information rebuild the fuel pump (Figure 1)

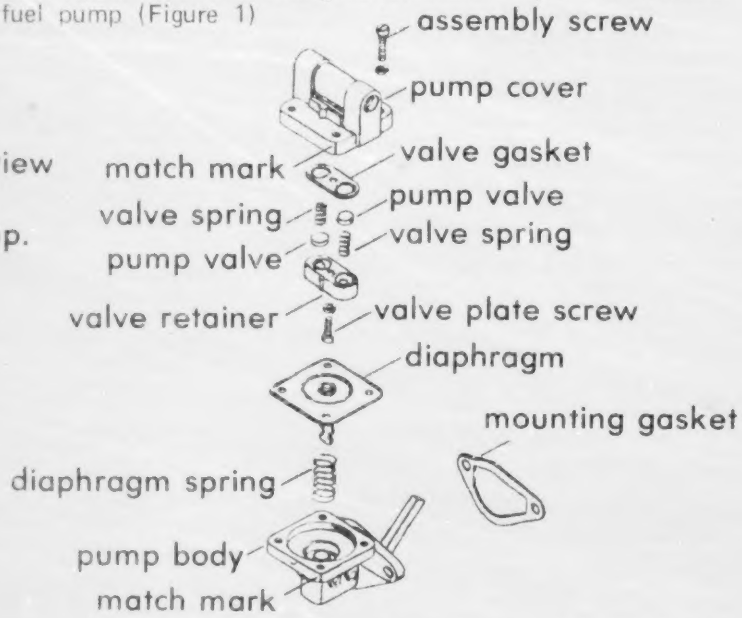

assembly screw
pump cover
match mark
valve gasket
pump valve
valve spring
valve spring
pump valve
valve retainer
valve plate screw
diaphragm
mounting gasket
diaphragm spring
pump body
match mark

FIGURE 1
Dissassembled view of a small engine fuel pump.

H. Mark the pump cover and body with a file; this prevents reversing the cover as it goes on the body

I. Replace pump

J. Clean up work area and replace tools in proper place

K. Have instructor check work

FUEL SYSTEMS
UNIT III

JOB SHEET #6--SERVICE SEDIMENT BOWL FUEL STRAINER

I. Tools and materials

   A. Hand tool assortment

   B. Solvents

   C. Pan for cleaning parts

   D. Cleaning rags

   E. New gasket for glass bowl

   F. Safety glasses

II. Procedure

   A. Disconnect and ground spark plug wire

   B. Close fuel shut-off valve

   C. Loosen jam nut and swing the wire bail to one side (Figure 1)

   D. Remove bowl with a twisting motion (Figure 1)

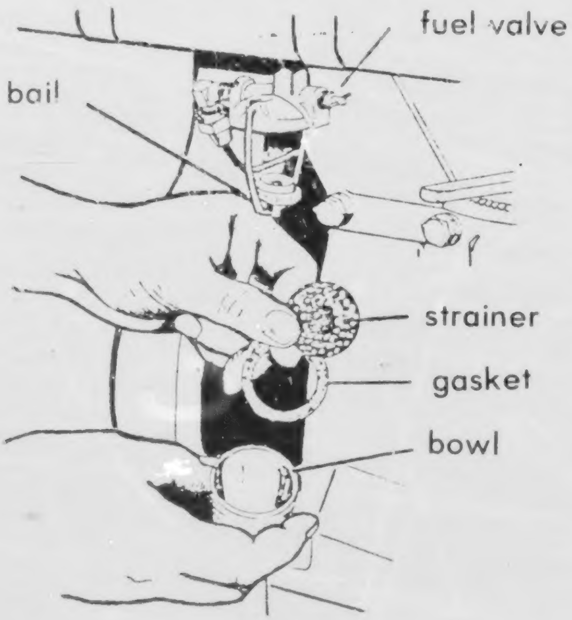


FIGURE 1

JOB SHEET #6

E. Remove gasket (Figure 1)

F. Remove strainer (filter) screen (Figure 1)

G. Wash the screen or filter element

H. Clean and then dry sediment bowl

I. Open fuel valve and drain out approximately a cup of fuel (Figure 2) (NOTE: Collect fuel in can to avoid a fire hazard.)

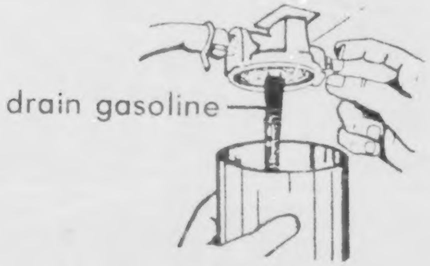


FIGURE 2

J. Install gasket, strainer, and sediment bowl (Figure 3)

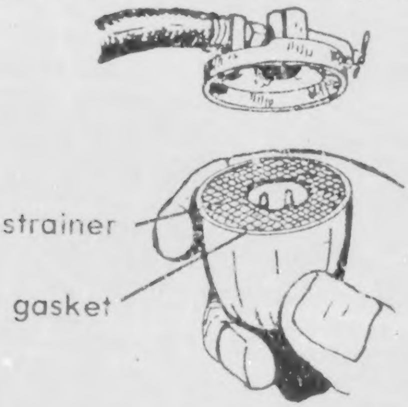


FIGURE 3

K. Fill the sediment bowl before tightening the jam nut

L. Tighten bowl against gasket with jam nut

M. Check for leaks before operating engine

N. Reconnect spark plug wire to spark plug

O. Operate engine for a few minutes and recheck for leaks

FUEL SYSTEM
UNIT III

TEST

1. Match the terms on the right to the correct definitions.

_____a. Correct proportion of fuel and air needed for good combustion

_____b. Restriction in the carburetor which makes the air speed up, causing a high vacuum

_____c. Breaking of a liquid into tiny particles or globules to aid vapor formation

_____d. Tube in a stream of air inside the venturi which creates an air pattern with low pressure on one side

_____e. Transferring a substance into a gaseous state

1. Venturi
2. Airfoil
3. Atomization
4. Vaporization
5. Metering

2. State the purpose of the fuel system.

3. List the three basic types of small engine fuel supply systems.

a.

b.

c.

4. List the purpose of each of the components of the fuel system.

a. Fuel tank--

b. Fuel filter--

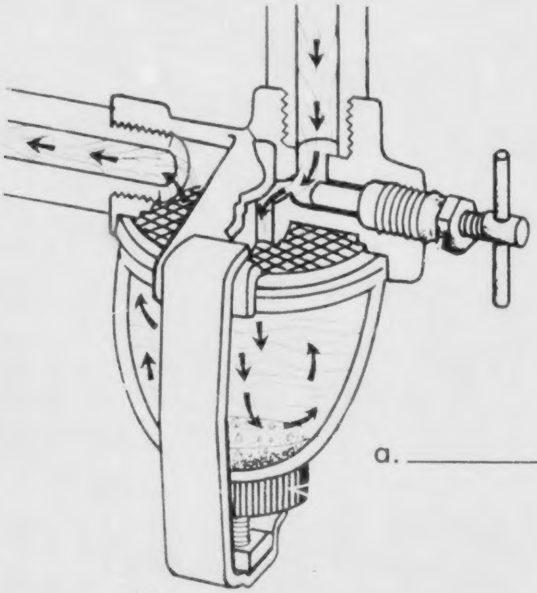
c. Carburetor--

d. Fuel pump--

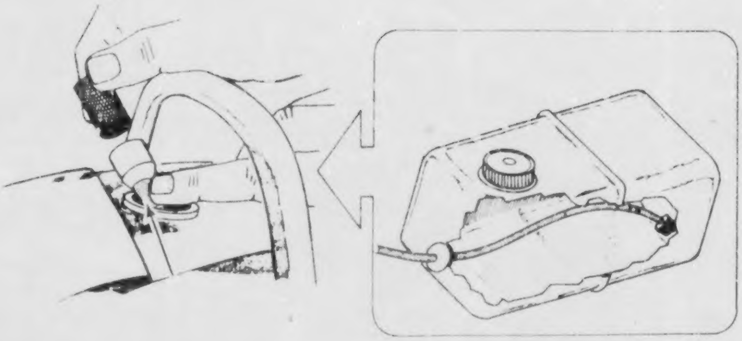
e. Fuel line--

f. Air cleaner--

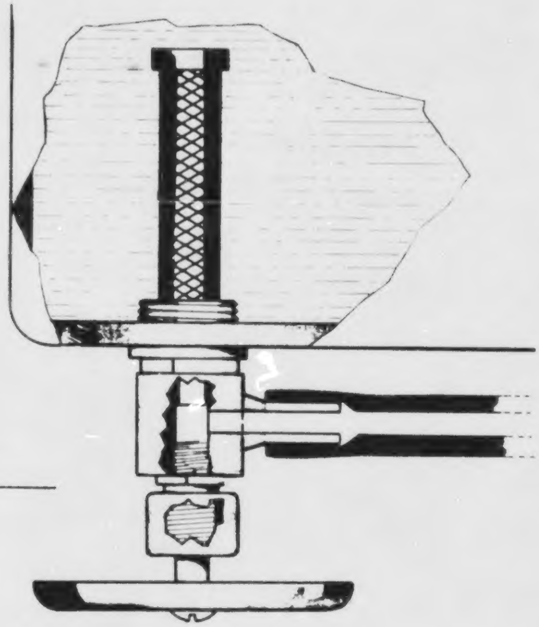
5. Identify three types of fuel filters.



a. ______________________



b. ______________________



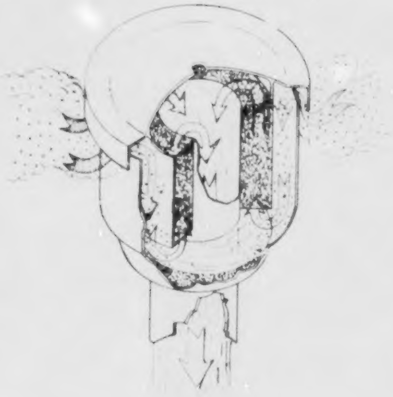
c. ______________________

6. Describe the fuel pump action during the inlet and outlet strokes.

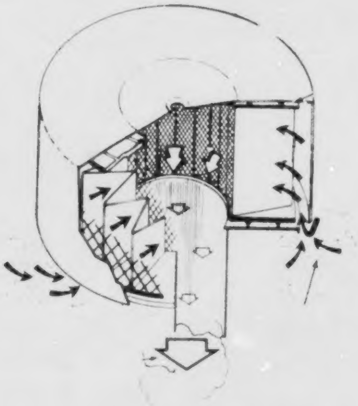
a. Inlet stroke

b. Outlet stroke

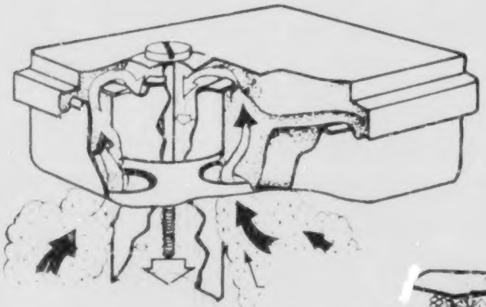
7. Identify three types of air cleaners.

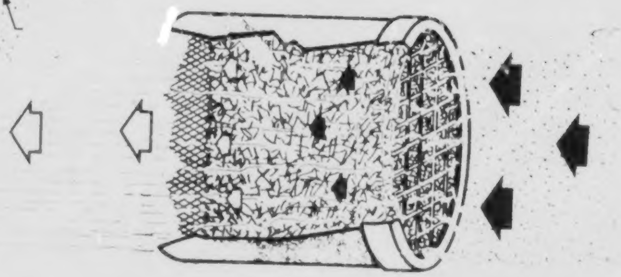


a. ____________________



____





c. ____________________

8. Identify the parts of the carburetor.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

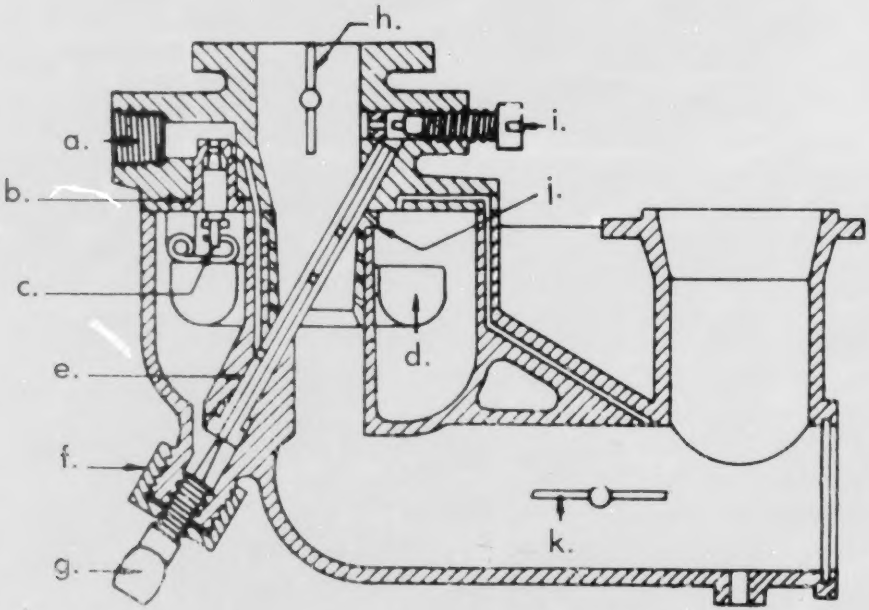
g. ____________________

h. ____________________

i. ____________________

j. ____________________

k. ____________________


h.
a.
i.
b.
j.
c.
d.
e.
f.
k.
g.

9. Match the carburetor systems on the right to the correct statements of their use.

_____a. Used when the engine is called upon to supply power for full, partial, or no-load at various operating speeds

_____b. Used to control the speed or power of an engine according to the requirements of the job it is to perform

_____c. Maintains a given depth of fuel in the float chamber

_____d. Provides a richer mixture for cold engine starting and operation

_____e. Provides fuel delivery during closed or nearly closed throttle operation

1. Float
2. Choke
3. High speed
4. Idle speed
5. Throttle

10. Demonstrate the ability to:

a. Service an air cleaner.

b. Remove and replace a carburetor.

c. Service float type carburetor.

d. Remove and replace a fuel pump.

e. Test and service a fuel pump.

f. Service sediment bowl fuel strainer.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

FUEL SYSTEMS
UNIT III

ANSWERS TO TEST

1. a. 5
   b. 1
   c. 3
   d. 2
   e. 4
2. The fuel system supplies a combustible mixture of air and fuel vapor to the engine cylinder(s)
3. a. Gravity feed
   b. Suction feed
   c. Pump feed
4. a. Fuel tank--Acts as reservoir to store fuel for engine use
   b. Fuel filter--Prevents dirt or foreign matter from entering the carburetor
   c. Carburetor--Automatically mixes fuel and air in the proper proportion for a combustible mixture
   d. Fuel pump--Pumps fuel from the fuel tank to the carburetor
   e. Fuel line--Carries fuel from the fuel tank to the carburetor
   f. Air cleaner--Filters grit and dust from the air entering the carburetor
5. a. Sediment bowl
   b. Filter attached to the end of flexible fuel hose (in tank)
   c. Screen in fuel tank
6. Description should include:
   a. Inlet stroke
      1) Diaphragm flexes downward, forming a vacuum
      2) Inlet check valve opens
      3) Fuel is drawn into pump

b. Outlet stroke
    1) Diaphragm pushed upward by return spring
    2) Inlet valve forced shut
    3) Outlet valve forced open
    4) Fuel is forced out of pump

7. a. Oil bath
    b. Paper element
    c. Polyurethane

8. a. Fuel inlet
    b. Float needle seat
    c. Float needle
    d. Float
    e. Nozzle
    f. Packing nut
    g. Needle valve
    h. Throttle valve
    i. Idle valve
    j. Venturi
    k. Choke valve

9. a. 3
    b. 5
    c. 1
    d. 2
    e. 4

10. Performance skills evaluated to the satisfaction of the instructor

GOVERNOR SYSTEMS
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to list purposes of the governor system, and identify the components of the governor system. The student should also demonstrate the ability to adjust and repair the governor system. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the governor system to the correct definitions.
2. List three purposes of the governor system.
3. List two types of governor systems.
4. Identify the components of the governor system.
5. Match the components of the governor systems to their purposes.
6. Demonstrate the ability to:
    - a. Inspect, adjust, and repair an air vane governor.
    - b. Inspect and adjust external components of a mechanical governor with internal flyweights.
    - c. Repair internal components of a mechanical governor with internal flyweights.
    - d. Inspect, adjust, and repair a centrifugal governor with external governor unit.

GOVERNOR SYSTEMS
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and job sheets

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Provide examples of both types of governors.

   H. Locate components of governor systems on live engines.

   I. Give test.

II. Student

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Identify components of governor systems on live engines.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Components of an Air Vane Governor System

      2. TM 2--Components of a Mechanical Governor System

D. Job sheets

1. Job Sheet #1--Inspect, Adjust, and Repair an Air Vane Governor
2. Job Sheet #2--Inspect and Adjust External Components of a Mechanical Governor with Internal Flyweights
3. Job Sheet #3--Repair Internal Components of a Mechanical Governor with Internal Flyweights
4. Job Sheet #4--Inspect, Adjust, and Repair a Centrifugal Governor with External Governor Unit

E. Test

F. Answers to test

II. References:

A. *Small Engines, Volume 2.* Athens Georgia: American Association for Vocational Instructional Materials, 1971.

B. *Small Engines Service Manual, 11th Edition.* Kansas City, Missouri: Intertec Publishing Corp., 1976.

GOVERNOR SYSTEMS
UNIT IV

INFORMATION SHEET

I. Terms and definitions

  A. Pneumatic--Moved or worked by air

  B. Centrifugal force--Action that tends to impel a thing or parts of a thing outward from a center of rotation

  C. Throttle--Lever controlling the throttle valve by linkage and spring adjustment

  (NOTE: The throttle controls the volume of vaporized fuel charge delivered to the cylinder.)

  D. Vane--Thin flat object that pivots about an axis by a flow of air

  E. Linkage--Series of rods, yokes, and levers used to transmit motion from one unit to another

II. Purposes of the governor system

  A. Maintains a speed selected by operator

  B. Prevents overspeeding that may cause engine damage

  C. Limits both high and low speeds

III. Types of governor systems (Transparencies 1 and 2)

  A. Air vane

  (NOTE: The air vane system operates by directing the air from the flywheel against the air vane.)

  B. Mechanical (centrifugal)

  (NOTE: The mechanical system operates by the use of centrifugal weights working against a spring.)

IV. Components of the governor system (Transparencies 1 and 2)

  A. Air vane governor

    1. Throttle control

    2. Control spring

    3. Air vane

INFORMATION SHEET

4. Throttle linkage
5. Flywheel

B. Mechanical (centrifugal governor)

1. Throttle control
2. Throttle rod
3. Throttle linkage
4. Control spring
5. Control arm
6. Flyweights
7. Throttle shaft

V. Purposes of each component of the governor system

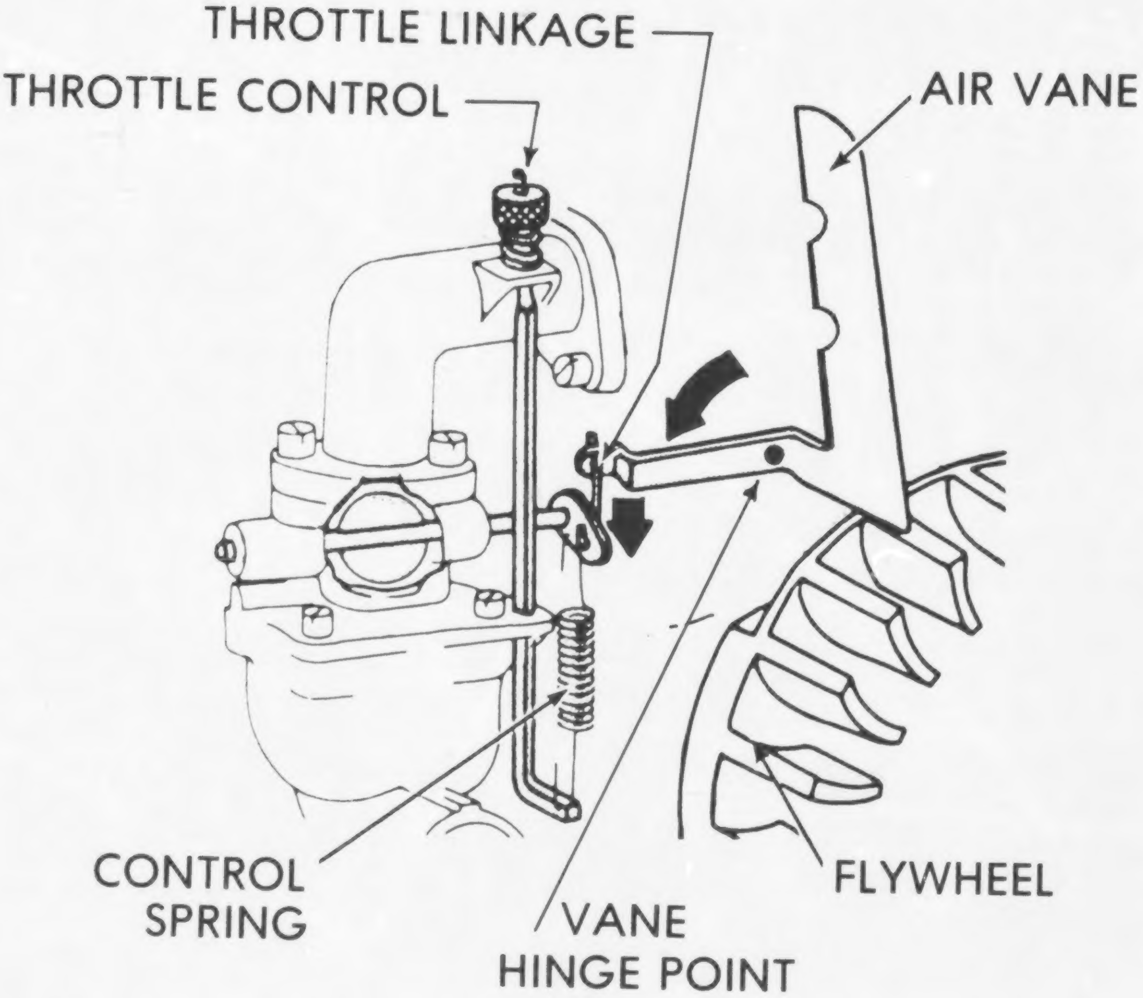
A. Air vane governor

1. Throttle control--Regulates engine speed
2. Control spring--Connection between throttle control and throttle valve shaft
3. Air vane--Senses air movement and opens or closes throttle
4. Linkage--Connects air vane to the throttle valve shaft
5. Flywheel--Provides pneumatic pressure in relationship to engine rpm

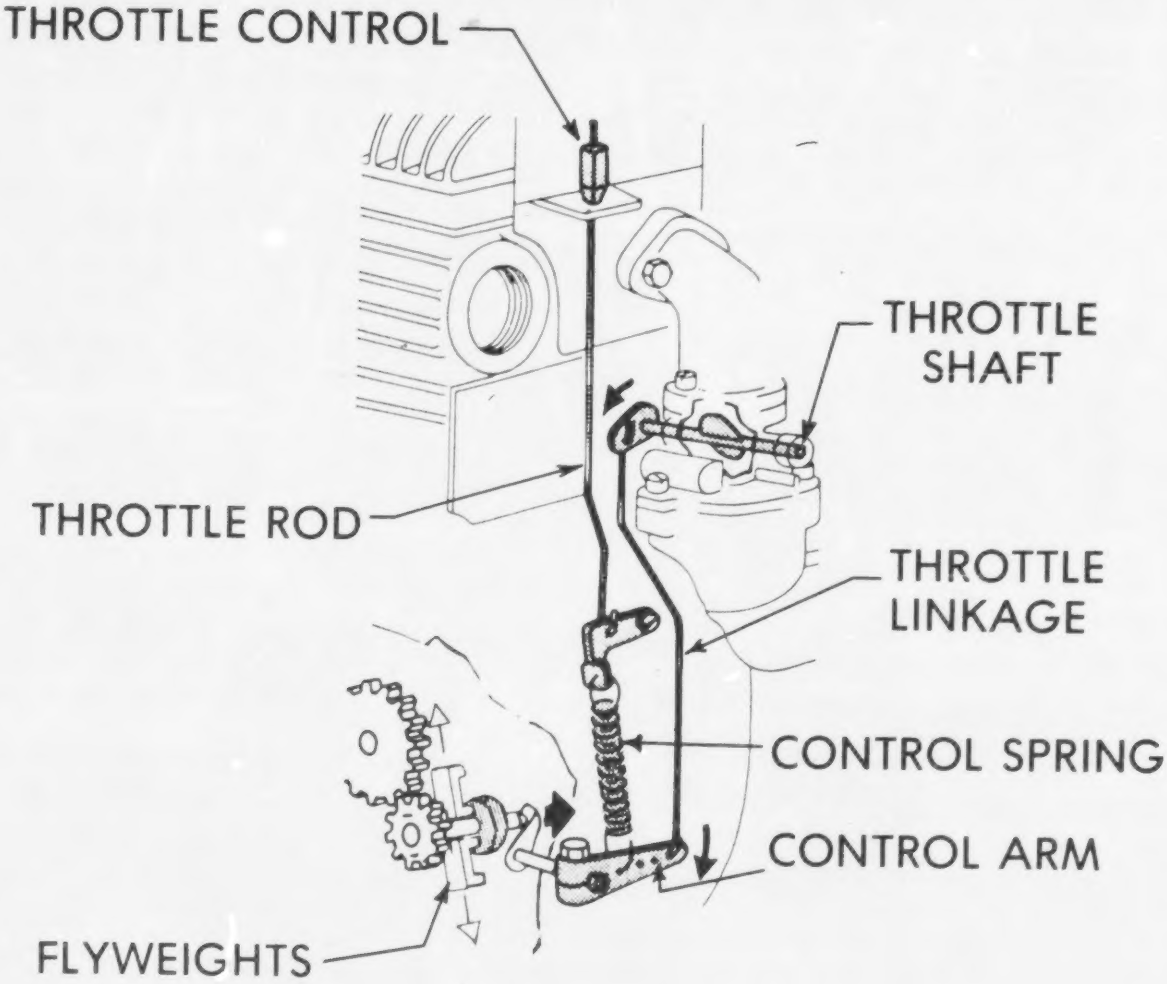
B. Mechanical governor

1. Throttle control--Regulates engine speed
2. Throttle rod--Transfers control adjustments to control spring
3. Throttle linkage--Connects control arm to throttle shaft
4. Control spring--Provides tension to control arm
5. Control arm--Transfers flyweight action to throttle link
6. Flyweights--Senses engine rpm and controls governor control arm

COMPONENTS OF AN AIR VANE GOVERNOR SYSTEM


THROTTLE LINKAGE
THROTTLE CONTROL
AIR VANE
CONTROL SPRING
VANE HINGE POINT
FLYWHEEL

COMPONENTS OF A MECHANICAL GOVERNOR SYSTEM


THROTTLE CONTROL
THROTTLE SHAFT
THROTTLE ROD
THROTTLE LINKAGE
CONTROL SPRING
CONTROL ARM
FLYWEIGHTS

GOVERNOR SYSTEMS
UNIT IV

JOB SHEET #1--INSPECT, ADJUST, AND REPAIR AN AIR VANE GOVERNOR

I. Tools and materials

   A. Hand tool assortment

   B. Tachometer

   (NOTE: A vibration tach or impulse tach may be used.)

   C. Safety glasses

   D. Appropriate service manual

II. Procedure

   A. Remove breather or air cleaner

   (NOTE: This may not be necessary in all cases, yet it usually will give a better view of linkage.)

   B. Remove blower shroud

   C. Check the condition of the linkage and controllers (Figure 1)

   (NOTE: Look for bent control rods, stretched springs, and pivot points where binding may occur. Straighten, lubricate and replace parts as necessary.)

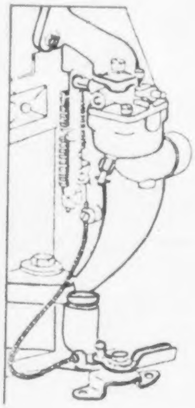


FIGURE 1

   D. Check air vane for freedom of movement and positioning

   (NOTE: Vane should be parallel to the crankshaft. Replace damaged parts as needed.)

   E. Replace blower shroud

JOB SHEET #1

F. Check to see if throttle valve is open while engine is not running

(NOTE: If valve is not open check for binding. If no binds exist adjust spring tension until valve is open. See Figure 2)

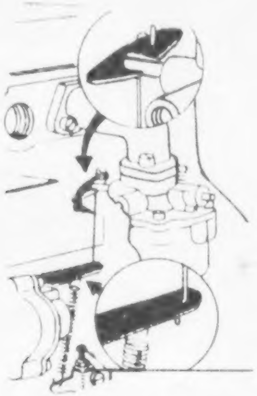


FIGURE 2

G. Replace breather

H. Find engine recommended speeds in manufacturer's service manual

I. Start engine

J. Check engine low idle speed with tachometer while throttle control is in closed position (Figure 3)

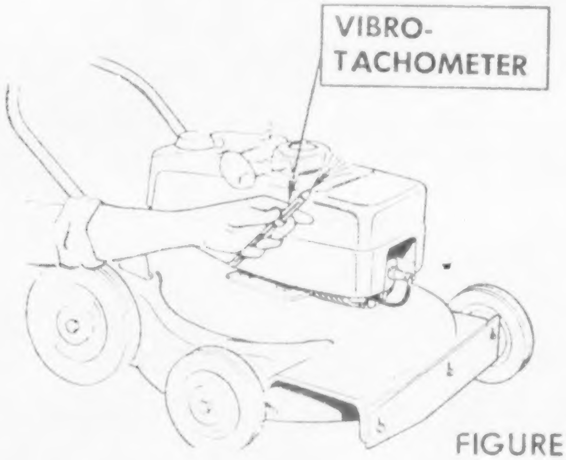


FIGURE 3

JOB SHEET #1

(NOTE: Check against manufacturer's specifications. Adjust idle stop screw at carburetor if your reading is not consistent with manufacturer's specifications. See Figure 4.)

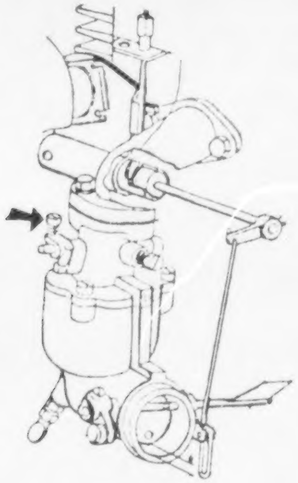


FIGURE 4

K. Check engine high idle no-load speed with tachometer while throttle control is fully open

(NOTE: Check against manufacturer's specifications. If engine overspeeds or surges the spring is too tight. If engine will not come up to speed, spring is too loose. Adjust to manufacturer's specifications.)

L. Shut off engine

M. Have instructor evaluate work

GOVERNOR SYSTEMS
UNIT IV

JOB SHEET #2 INSPECT AND ADJUST EXTERNAL COMPONENTS OF A MECHANICAL GOVERNOR WITH INTERNAL FLYWEIGHTS

I. Tools and materials

  A. Hand tool assortment

  B. Tachometer

  C. Appropriate service manual

  D. Safety glasses

II. Procedure

(NOTE: Before dissassembling engines to repair internal flyweights be sure that the fuel system and external governor components have thoroughly been inspected.)

  A. Remove breather

  (NOTE: This may not be necessary in all cases, however it usually will give a better view of linkage.)

  B. Check condition of linkage and controllers

  (NOTE: Look for bent control rods, stretched springs, and pivot points where binding may occur. Straighten, lubricate and replace parts as necessary.)

  C. Check to see if throttle valve is open while engine is at rest

  D. Adjust throttle to open position if necessary (Figure 1)

    1. Loosen screw clamping control arm to governor rod

    2. Turn control arm until carburetor throttle is in wide open position

    (NOTE: Check appropriate service manual for direction of rotation.)

    3. Turn crank on governor rod counterclockwise as far as possible

    4. Tighten screw connecting control arm to governor rod

JOB SHEET #2

5. Check linkage for freedom

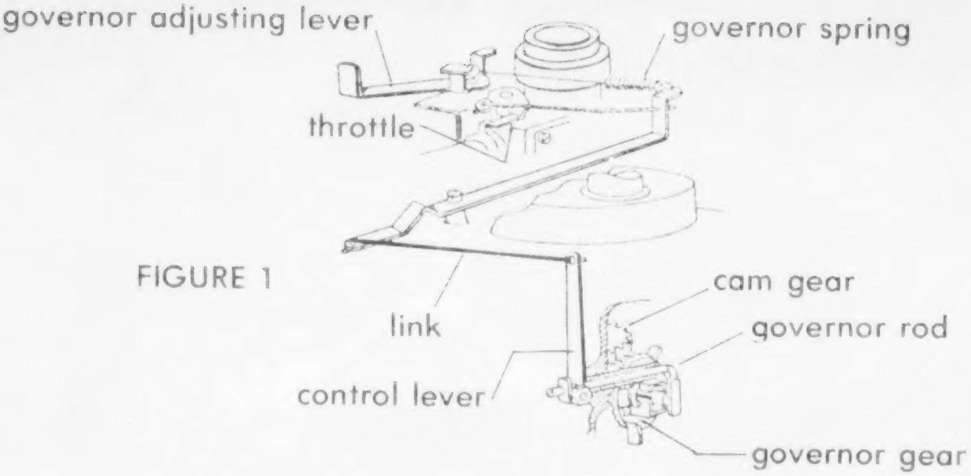

governor adjusting lever
governor spring
throttle
cam gear
link
governor rod
control lever
governor gear

FIGURE 1

E. Find recommended engine speeds in service manuals

F. Replace breather or air cleaner

G. Start engine

H. Check engine low idle speed with tachometer while engine throttle control is in closed position

(NOTE: Adjust idle stop screw at carburetor if idle speed does not correspond with manufacturer's specification.)

I. Check engine high idle no-load with tachometer while engine control level is in full throttle position

(NOTE: If engine overspeeds or surges, spring is too tight. If engine will not come up to speed the spring is too loose. Adjust to manufacturer's specifications. Be sure carburetor is properly adjusted.)

J. Shut off engine

K. Have instructor evaluate work

GOVERNOR SYSTEMS
UNIT IV

JOB SHEET #3--REPAIR INTERNAL COMPONENTS OF A MECHANICAL GOVERNOR WITH INTERNAL FLYWEIGHTS

I. Tools and materials

A. Hand tool assortment

B. Oil drain pan

C. Shop towels

D. Fresh oil

E. Solvent

F. Parts cleaning brush

G. Water supply and hose

H. Safety glasses

II. Procedure

A. Remove engine from equipment

B. Place engine oil reservoir drain plug over drain pan

C. Remove plug and drain oil

(NOTE: Dispose of used oil properly.)

D. Replace plug

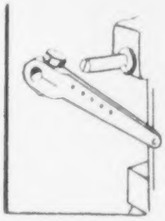
E. Clean engine exterior with solvent and brush

(NOTE: Allow solvent to penetrate hard deposits.)

F. Hose off solvent and dirt

G. Loosen securing bolt and disconnect control lever from governor rod (Figure 1)

FIGURE 1



JOB SHEET #3

H. Remove side housing bolts

I. Remove governor unit

(NOTE: Internal governor units come in a variety of styles, however basic components are quite similar. See Figures 2 and 3)

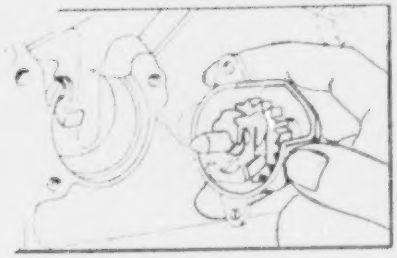


FIGURE 2

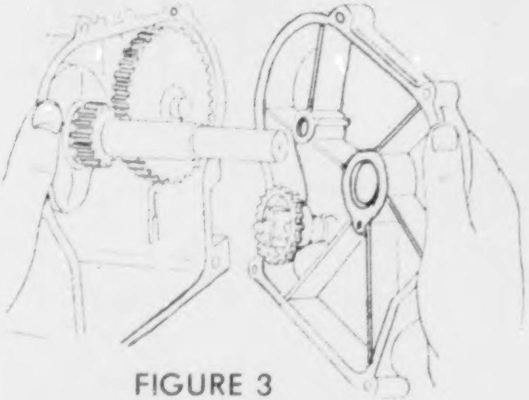


FIGURE 3

J. Check governor unit for wear and damage (Figure 4)

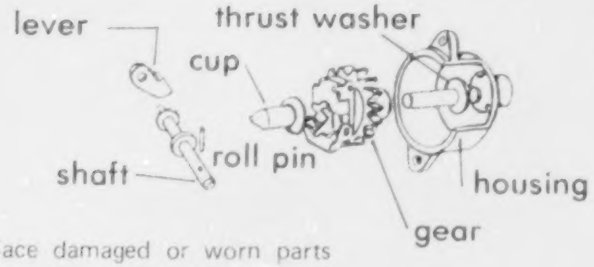


FIGURE 4

K. Replace damaged or worn parts

(NOTE: Check thrustwashers for wear or damage.)

L. Reinstall governor unit on the housing

M. Place housing back on the engine block

(NOTE: Replace gasket if torn or damaged, and refer to appropriate service manual for bolt torque specifications.)

N. Install the housing bolts

O. Put control lever on governor rod

P. Put oil in engine

Q. Adjust external components

GOVERNOR SYSTEMS
UNIT IV

JOB SHEET #4--INSPECT, ADJUST, AND REPAIR A CENTRIFICAL GOVERNOR WITH EXTERNAL GOVERNOR UNIT

I. Tools and materials

   A. Hand tool assortment

   B. Flywheel puller

   C. Flywheel holder

   D. Flywheel wrench

   E. Solvent

   F. Parts cleaning brush

   G. Water supply and hose

   H. Tachometer

   I. Appropriate service manual

   J. Safety glasses

   K. Compressed air

II. Procedure

   (NOTE: This is a general job sheet for engines with governor unit located under flywheel.)

   A. Clean engine with solvent and brush

      (NOTE: Allow solvent to soak long enough to loosen caked deposits.)

   B. Hose off solvent and dirt

   C. Dry with compressed air

   D. Remove spark plug wire and ground it to block

   E. Remove blower shroud

JOB SHEET #4

F. Loosen flywheel nut

(NOTE: Tapping a breakover wrench with a mallet will often break it loose.)

G. Remove flywheel nut

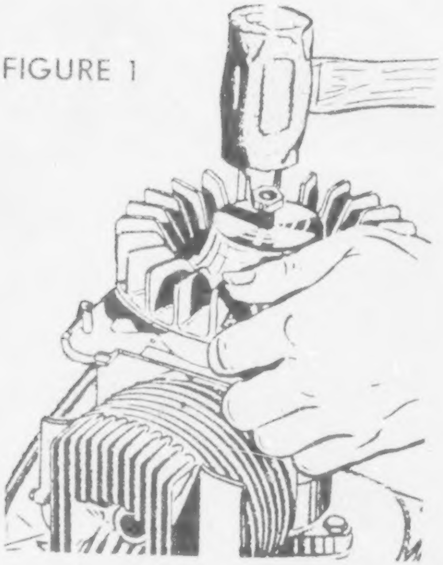
(NOTE: Use a flywheel holder if nut is hard to remove.)

H. Remove flywheel

1. Tapered shaft (Figure 1)

   (NOTE: Start flywheel nut on shaft and gently tap it while lifting on flywheel. Use a lead or plastic hammer. If the flywheel does not break loose after two or three tries, use a puller.)

FIGURE 1



JOB SHEET #4

2. Untapered shaft (Figures 2 and 3)

(NOTE: This may require a special puller; refer to service manual.)

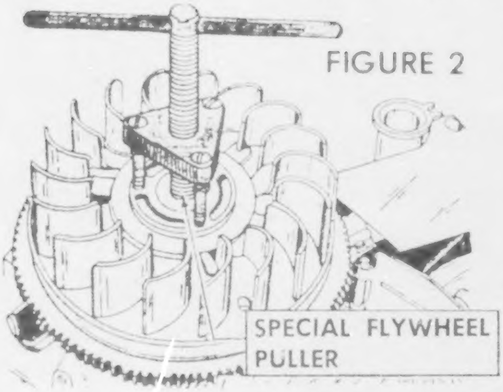


FIGURE 2

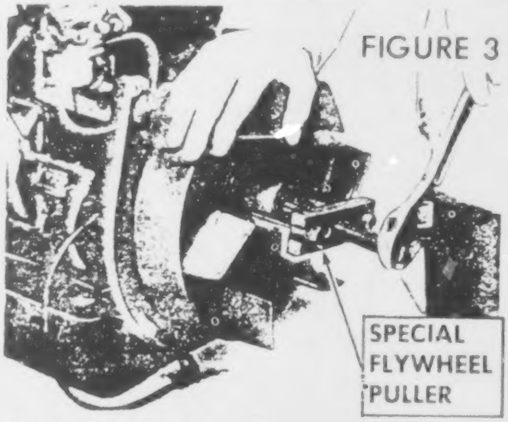


FIGURE 3

I. Inspect linkages and control lever clearances

(NOTE: Refer to appropriate service manual for exact specifications.)

J. Inspect governor unit parts

(NOTE: Look for points of wear. Replace damaged or worn parts. Consult appropriate service manual for exact specifications.)

K. Inspect flywheel recess

(NOTE: Roughness or burrs can effect operation of some models.)

L. Check throttle position

(NOTE: While engine is at rest throttle should be in full open position.)

M. Adjust throttle position if necessary

(NOTE: Refer to appropriate service manual for exact procedures.)

N. Lubricate all moving parts

O. Replace flywheel

P. Replace flywheel nut

(NOTE: Refer to appropriate service manual for torquing specifications.)

Q. Replace blower shroud

R. Connect spark plug wire

JOB SHEET #4

S. Find recommended speed in service manual

T. Start engine

U. Check engine low idle speed with tachometer while throttle control is in closed position

(NOTE: Check against manufacturer's recommendations. If the reading is not consistent adjust idle stop screw at carburetor.)

V. Check engine high idle no-load speed with tachometer while throttle control is in full open position

(NOTE: Adjust governor spring until manufacturer's specifications are met.)

W. Turn off engine

X. Have instructor evaluate work

GOVERNOR SYSTEMS
UNIT IV

NAME ____________________

TEST

1. Match the terms on the right to the correct definitions.

   _____a. Moved or worked by air

   _____b. Thin flat object that pivots about an axis by a flow of air

   _____c. Series of rods, yokes, and levers used to transmit motion from one unit to another

   _____d. Action that tends to impel a thing or parts of a thing outward from a center of rotation

   _____e. Lever controlling the throttle valve by linkage and spring adjustment

   1. Linkage
   2. Pneumatic
   3. Vane
   4. Centrifugal force
   5. Throttle

2. List three purposes of the governor system.

   a.

   b.

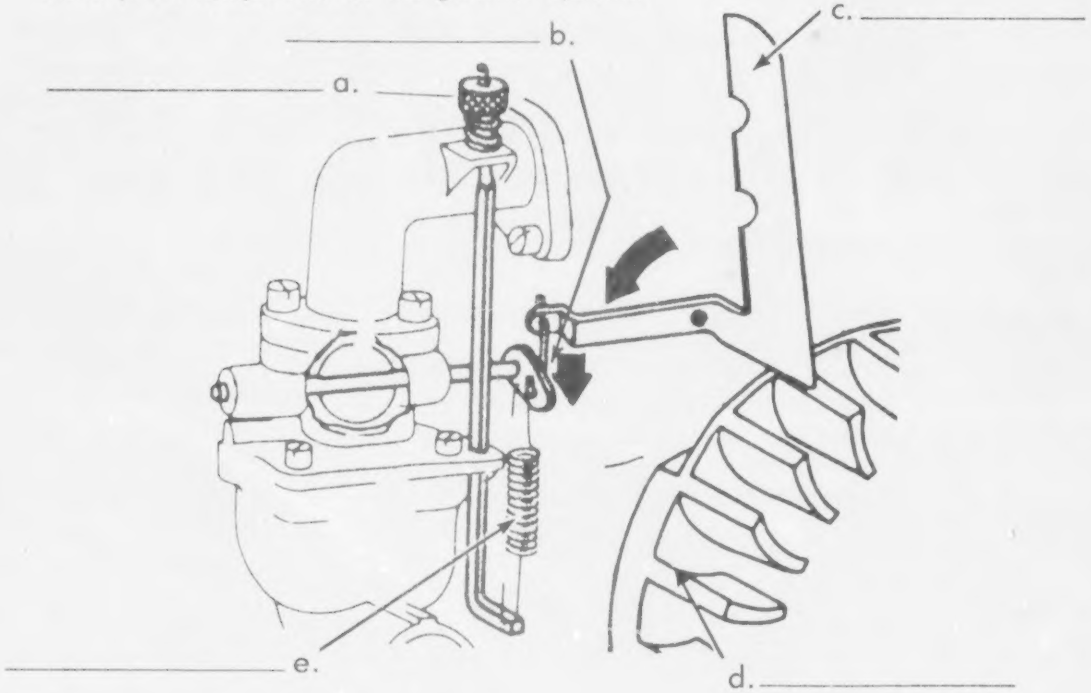
   c.

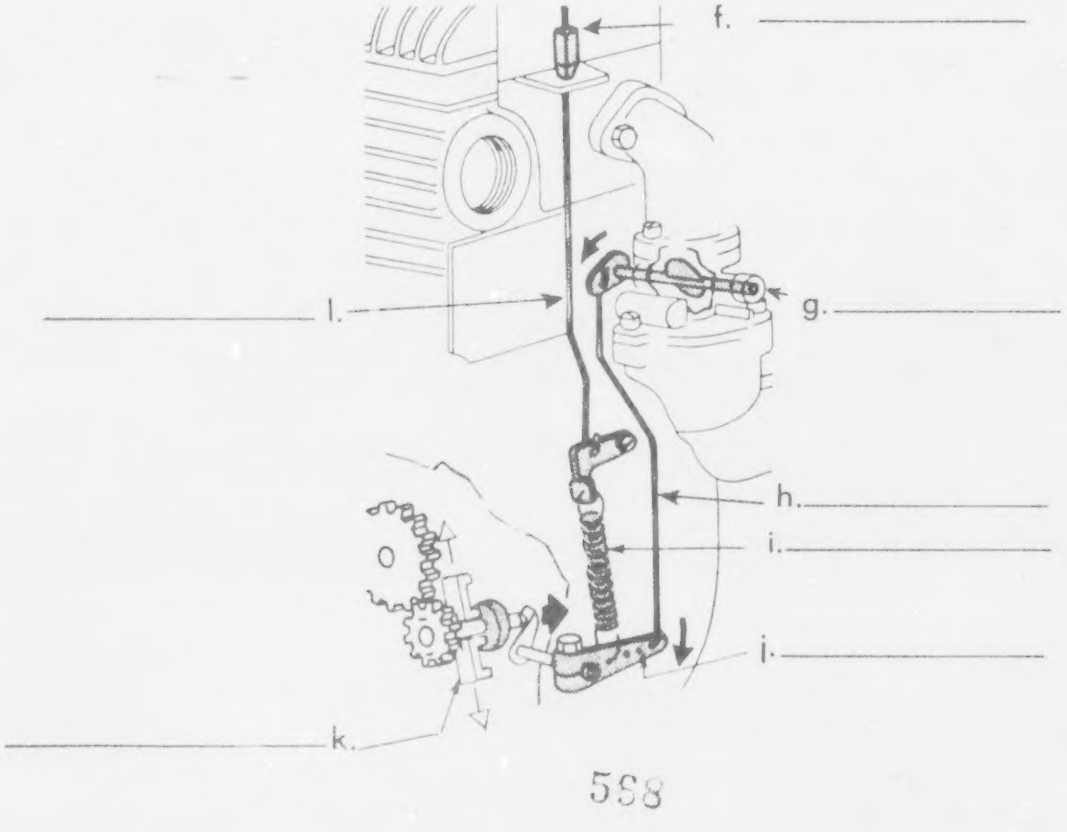
3. List two types of governor systems.

   a.

   b.

4. Identify the components of the governor systems.





5. Match the components of the governor systems on the right to their correct purposes.

a. Air vane

_____1) Connection between throttle control and throttle valve shaft

_____2) Connects air vane to the throttle valve shaft

_____3) Provides pneumatic pressure in relationship to engine rpm

_____4) Senses air movement and opens or closes throttle

_____5) Regulates engine speed

a) Control spring

b) Flywheel

c) Linkage

d) Air vane

e) Throttle control

b. Mechanical

_____1) Transfers control adjustments to control spring

_____2) Provides tension to control arm

_____3) Senses engine rpm and controls governor control arm

_____4) Regulates engine speed

_____5) Connects control arm to throttle shaft

_____6) Transfers flyweight action to throttle link

a) Flyweights

b) Control arm

c) Control spring

d) Throttle linkage

e) Throttle rod

f) Throttle control

6. Demonstrate the ability to:

a. Inspect, adjust, and repair an air vane governor.

b. Inspect and adjust external components of a mechanical governor with internal flyweights.

c. Repair internal components of a mechanical governor with internal flyweights.

d. Inspect, adjust, and repair a centrifugal governor with external governor unit.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

GOVERNOR SYSTEMS
UNIT III

ANSWERS TO TEST

1. a. 2
   b. 3
   c. 1
   d. 4
   e. 5

2. a. Maintains a speed selected by operator
   b. Prevents overspeeding that may cause engine damage
   c. Limits both high and low speeds

3. a. Air vane
   b. Mechanical (centrifugal)

4. a. Throttle control
   b. Throttle linkage
   c. Air vane
   d. Flywheel
   e. Control spring
   f. Throttle control
   g. Throttle shaft
   h. Throttle linkage
   i. Control spring
   j. Control arm
   k. Flyweights
   l. Throttle rod

5. a. 1) a
      2) c
      3) b
      4) d
      5) e
   b. 1) e
      2) c

3) a

4) f

5) d

6) b

6. Performance skills to be evaluated to the satisfaction of the instructor.

EXHAUST SYSTEM
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to list purposes of the exhaust systems, select types of exhaust systems, and perform maintenance procedures on the exhaust system. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the exhaust system to the correct definitions.
2. List four purposes of the exhaust system.
3. List two results that can occur from running a worn or damaged exhaust system.
4. Select the types of exhaust systems.
5. State the danger of operating an engine in a closed shop.
6. Demonstrate the ability to remove, service, and replace two cycle exhaust system components.

EXHAUST SYSTEM
UNIT V

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Discuss unit and specific objectives.

  D. Discuss information sheet.

  E. Demonstrate and discuss the procedure outlined in the job sheet.

  F. Discuss variations in exhaust systems.

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete job sheet.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Job Sheet #1--Remove, Service, and Replace Two Cycle Exhaust System Components

  D. Test

  E. Answers to test

II. Reference--*Small Engines, Volume I.* Athens, Georgia: American Association for Vocational Instructional Materials, 1971.

EXHAUST SYSTEM
UNIT V

INFORMATION SHEET

I. Terms and definitions

A. Exhaust valve--Valve which seals burning gases within cylinder until its energy has been expended, then opens so the cylinder can clear

B. Exhaust manifold--Receives and carries away burned gases

C. Exhaust pipe--Pipe connecting exhaust manifold to muffler

D. Muffler--Carries away exhaust gases and heat, and muffles engine noise

E. Tail pipe--Pipe from muffler that carries exhaust fumes away from equipment

F. Exhaust port--Hole in cylinder wall that allows exhaust gases to escape

II. Purposes of exhaust system

A. Removes heat

B. Muffles engine sounds

C. Carries away burned and unburned gases

D. Acts as scavenger

III. Results from running a worn or damaged exhaust system

A. Loss of power

B. Possible engine damage

IV. Types of exhaust systems

A. Straight through

B. Reverse flow

C. Expansion chamber

V. Operating an engine in a closed shop--Exhaust gases contain carbon monoxide, a deadly poison

(NOTE: Engines should not be operated in a closed shop; proper ventilation should be used for running engines.)

EXHAUST SYSTEM
UNIT V

JOB SHEET #1--REMOVE, SERVICE, AND REPLACE TWO CYCLE EXHAUST SYSTEM COMPONENTS

I. Tools and materials

A. Hand tool assortment

B. Hardwood scraper

C. Carbon solvent

D. Compressed air

E. Safety glasses

II. Procedure

A. Remove muffler and any mounting gaskets (Figure 1)

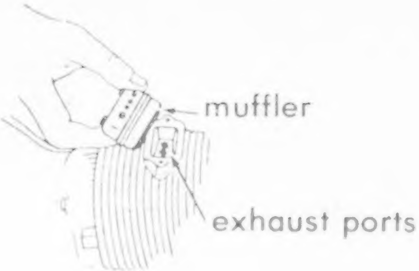


FIGURE 1
Removal of muffler to inspect exhaust ports of a two-stroke cycle engine

B. Rotate crankshaft until piston covers exhaust ports

JOB SHEET #1

C. Using the wood scraper remove carbon from ports (Figure 2)

(NOTE: Do not use a metal scraper as this will scratch the piston or damage the exhaust port edges.)

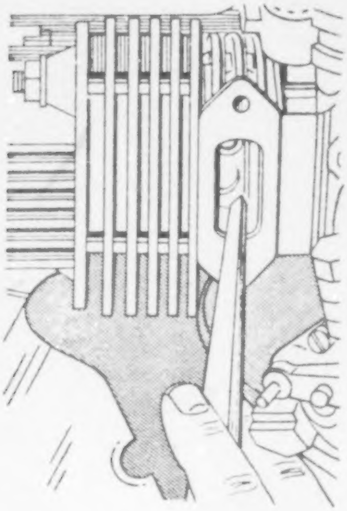


FIGURE 2

Use a hardwood scraper to remove carbon from the exhaust ports

D. Hold engine with port down so carbon will fall out

E. Blow out the ports with compressed air

F. Soak muffler in solvent to remove carbon deposits

(NOTE: A screwdriver or scraper may be used on large deposits. See Figure 3.)

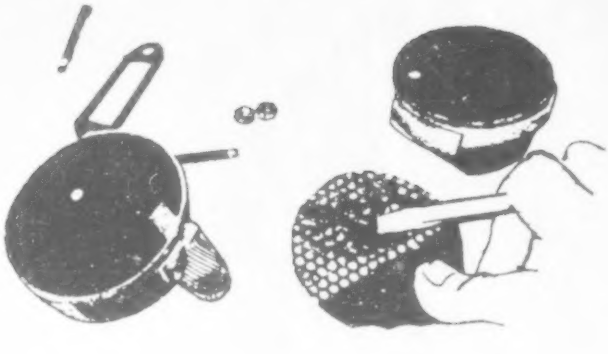


FIGURE 3

JOB SHEET #1

G. Wash muffler with warm water

H. Reinstall muffler using new gaskets where needed

(NOTE: When installing mufflers on four cycle engines, use a locknut to prevent seizing of the muffler in the block. Discard damaged or worn out system components. Use anti-seize compound on bolts.)

I. Have instructor evaluate work

EXHAUST SYSTEM
UNIT V

NAME ____________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Valve which seals burning gases within cylinder until its energy has been expended, then opens so the cylinder can clear

_____b. Receives and carries away burned gases

_____c. Pipe connecting exhaust manifold to muffler

_____d. Carries away exhaust gases and heat, and muffles engine noise

_____e. Pipe from muffler that carries exhaust fumes away from equipment

_____f. Hole in cylinder wall that allows exhaust gases to escape

1. Exhaust manifold
2. Muffler
3. Tail pipe
4. Exhaust pipe
5. Exhaust port
6. Exhaust valve

2. List four purposes of the exhaust system.

a.

b.

c.

d.

3. List two results that can occur from running a worn or damaged exhaust system.

a.

b.

4. Select the types of exhaust systems by placing an "X" in the appropriate blanks.

_____a. Diagonal flow

_____b. Straight through

_____c. Looped flow

_____d. Expansion chamber

_____e. Reverse flow

5. State the danger of operating an engine in a closed shop.

6. Demonstrate the ability to remove, service, and replace two cycle exhaust system components.

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

EXHAUST SYSTEM
UNIT V

ANSWERS TO TEST

1. a. 6
   b. 1
   c. 4
   d. 2
   e. 3
   f. 5
2. a. Removes heat
   b. Muffles engine sounds
   c. Carries away burned and unburned gases
   d. Acts as scavenger
3. a. Loss of power
   b. Possible engine damage
4. b, d, e
5. Exhaust gases contain carbon monoxide, a deadly poison
6. Performance skills evaluated to the satisfaction of the instructor

TROUBLESHOOTING
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to troubleshoot engine problems. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Define troubleshooting.
2. Select requirements for an engine to run.
3. List seven basic troubleshooting procedures.
4. Discuss the importance of understanding troubleshooting procedures.
5. Demonstrate the ability to troubleshoot an engine problem.

TROUBLESHOOTING
UNIT VI

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Discuss unit and specific objectives.

  D. Discuss information and job sheets.

  E. Show students examples of troubleshooting charts from service manuals.

  F. Discuss troubleshooting charts.

  G. Invite a potential employer to discuss importance of sound troubleshooting techniques.

  H. Take students on field trip to visit shop and observe troubleshooting techniques.

  I. Give test.

II. Student

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Job Sheet #1--Troubleshoot an Engine Problem

  D. Test

  E. Answers to test

II. References

A. *Hydraulics.* Moline, Illinois: Deere and Company, 1972.

B. *Chilton's Motorcycle Troubleshooting Guide.* Radnor, Pennsylvania: Chilton Book Company, 1973.

TROUBLESHOOTING
UNIT VI

INFORMATION SHEET

I. Troubleshooting--Troubleshooting is the systematic diagnosis of engine malfunctions

II. Requirements for an engine to run

   A. Compression

   B. Ignition

   C. Carburetion

   (NOTE: Troubleshooting involves checking for the presence of these things plus their timing as they enter the cylinder.)

III. Basic troubleshooting procedures

   A. Know the engine

   (NOTE: This may involve the study of an engine's service manual if you are not already familiar with its design features. A good service person keeps up with the latest service bulletins.)

   B. Ask the operator

   (NOTE: Ask the operator how, when and where the problem occurs or first started. Usually there will be some symptoms that lead to the troubleshooting problem.)

   C. Inspect the engine

   (NOTE: Check oil level, fuel level, and coolant level if equipped. Look for clogged breathers and fuel system vent caps, loose hoses, manifolds and wire connections while inspecting.)

   D. Operate the engine if possible

   (NOTE: Listen to the sounds it makes while running as well as looking for erratic behavior, oil leaks, or unusual emissions.)

   E. List possible causes

   (NOTE: Put down all the symptoms and visible possibilities.)

   F. Formulate a conclusion

   (NOTE: Remember when looking at the list of possible causes that one failure often leads to or indicates another problem.)

INFORMATION SHEET

G. Test conclusion

(NOTE: Before you start repairing the engine, analyze the information you have and test your conclusion if possible. Be a troubleshooter, not a hit and miss person.)

IV. Importance of understanding troubleshooting procedures

A. Saves customer's money

(NOTE: The alternative to troubleshooting is parts exchanging. If you don't solve the problem on first or second exchange it gets expensive.)

B. Insures a better repair job

1. Total system or engine is observed

(NOTE: This provides more opportunity to find weak or failing parts.)

2. Better operating dependability

(NOTE: Thorough troubleshooting provides for the identification of problems which may hinder proper engine operations in the future.)

C. Makes employees more valuable

1. Good service means continued business with present customers plus the drawing of new customers

2. Less work is returned

TROUBLESHOOTING
UNIT VI

JOB SHEET #1--TROUBLESHOOT AN ENGINE PROBLEM

(NOTE: This is a general job sheet designed to provide practice in using sound troubleshooting procedures.)

I. Tools and materials

   A. Basic hand tool assortment

   B. Appropriate service manual

   C. Safety glasses

II. Procedure

   A. Familiarize yourself with the engine

      1. Secure appropriate service manuals

      2. Review current service bulletins

   B. Ask the operator about the engine's performance

      1. Ask about performance prior to the problem

      2. Ask about problem symptoms

      3. Inquire about maintenance procedures

      4. Inquire about how engine is used

   C. Inspect the engine

      1. Check oil levels

      2. Look for intake restrictions

      3. Check for faulty fuel system

      4. Check all hoses to be sure they are secure

   D. Operate the engine if possible

      1. Listen for unusual sounds

      2. Look for abnormal emissions

      3 Look for leaks

JOB SHEET #1

E. List possible problem causes

(NOTE: Use your knowledge of the engine plus information received from the troubleshooting techniques used to this point.)

F. Formulate a conclusion

1. Review list of probable causes
2. Select cause

G. Test conclusion

(NOTE: Test the conclusion you have reached before repairing engine if possible.)

TROUBLESHOOTING
UNIT VI

TEST

1. Define troubleshooting.

2. Select requirements for an engine to run by placing an "X" in the appropriate blanks.

______a. Ignition

______b. Speed

______c. Compression

______d. Carburetion

______e. Centrifugal force

______f. Pulley

3. List seven basic troubleshooting procedures.

a.

b.

c.

d.

e.

f.

g.

4. Discuss the importance of understanding troubleshooting procedures.

5. Demonstrate the ability to troubleshoot an engine problem.

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

TROUBLESHOOTING
UNIT VI

ANSWERS TO TEST

1. Troubleshooting is the systematic diagnosis of engine malfunctions

2. a, c, d

3. a. Know the engine

   b. Ask the operator

   c. Inspect the engine

   d. Operate the engine if possible

   e. List possible causes

   f. Formulate a conclusion

   g. Test conclusion

4. Discussion should include:

   a. Saves customer's money

   b. Insures a better repair job

      1) Total system or engine is observed

      2) Better operating dependability

   c. Makes employees more valuable

      1) Good service means continued business with present customers plus the drawing of new customers

      2) Less work is returned

5. Performance skill evaluated to the satisfaction of the instructor.

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VII

UNIT OBJECTIVE

After completion of this unit, the student should be able to disassemble and reassemble a four-stroke cycle engine and inspect and service the cylinder, piston, rings, connecting rod, crankshaft assembly, and valve train. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with overhaul of a four-stoke cycle engine to the correct definitions.
2. List five causes of engine problems.
3. Identify the parts of the piston and connecting rod assembly.
4. Identify the parts of the crankshaft assembly.
5. Identify the parts of a multi-piece crankshaft assembly.
6. Identify the parts of the valve train.
7. Demonstrate the ability to:
    a. Disassemble a four-stroke cycle engine.
    b. Inspect and service a cylinder.
    c. Inspect and service the piston, rings, and connecting rod.
    d. Inspect and service a crankshaft asembly.
    e. Service a multi-piece crankshaft assembly.
    f. Inspect and service a valve assembly.
    g. Reassemble a four-stroke cycle engine.

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VII

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheet.
- F. Demonstrate and discuss the procedures outlined in the job sheets.
- G. Provide examples of pistons and connecting rod assemblies, crankshaft assemblies, and valve trains.
- H. Compare overhauls of four-stroke cycle and two-stroke cycle engines.
- I. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
  - 1. TM 1--Piston and Rod Assembly
  - 2. TM 2--Connecting Rod Assembly

3. TM 3--Crankshaft Assembly

4. TM 4--Multi-piece Crankshaft Assembly

5. TM 5--Valve Train

D. Job sheets

1. Job Sheet #1--Disassemble a Four-stroke Cycle Engine

2. Job Sheet #2--Inspect and Service a Cylinder

3. Job Sheet #3--Inspect and Service the Piston, Rings, and Connecting Rod

4. Job Sheet #4--Inspect and Service a Crankshaft Assembly

5. Job Sheet #5--Service a Multi-piece Crankshaft Assembly

6. Job Sheet #6--Inspect and Service a Valve Assembly

7. Job Sheet #7--Reassemble a Four-Stroke Cycle Engine

E. Test

F. Answers to test

II. References:

A. *Harley-Davidson Service Manual: Sportster XL/XLH/XLCX, 1970-1973.* Harley Davidson Motor Co. Inc., 1972.

B. *Small Engines, Volume 2.* Athens, Georgia: American Association of Vocational Instructional Materials, 1974.

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VII

INFORMATION SHEET

I. Terms and definitions

   A. Overhaul--To restore to manufacturer's specifications

   B. Abrasion--Wearing or rubbing away

   C. Anti-friction bearing--Bearing constructed with balls or rollers between journal and bearing surface to provide rolling instead of sliding friction

   D. Babbit--Alloy of tin, copper, lead, silver, and antimony having good anti-friction properties; used as a facing for bearings

   E. Backlash--Clearance or "play" between two parts

      Example: Meshed gears

   F. Blow-by--Leakage or loss of pressure

      (NOTE: This is often used with reference to leakage of compression past piston ring between piston and cylinder.)

   G. Break in--Process of wearing into a desirable fit new or reconditioned parts

   H. Bushing--Removable sleeve used as a bearing

   I. Camshaft--Shaft containing lobes or cams which operate engine valves

   J. Carbon--Common nonmetallic element which forms in combustion chamber of an engine during burning of fuel and lubricating oil

   K. Clearance--Space allowed between two parts

      Example: Space between a journal and a bearing

   L. Crankshaft counterbalance--Series of weights attached to or forged integrally with the crankshaft, placed so as to offset the reciprocating weight of each piston and rod assembly

   M. Floating piston pin--Piston pin which is not locked in the connecting rod or the piston, but is free to turn or oscillate in both the connecting rod and the piston

   N. Gasket--Substance placed between two metal surfaces to act as a seal

INFORMATION SHEET

O. Hone--Abrasive tool for correcting irregularities or differences in diameter in cylinder

Example: Engine cylinder

P. Interference angle--Difference in angle between mating surfaces of a valve and a valve seat

Q. Journal--Part of a shaft or crank which rotates inside a bearing

R. Oil pumping--Term used to describe an engine which is using an excessive amount of lubricating oil

S. Piston slap--Rocking of loose fitting piston in a cylinder, making a hollow bell like sound

T. Press fit--Known as a force fit or drive fit

(NOTE: This fit is accomplished by forcing a shaft into a hole slightly smaller than the shaft.)

U. Running fit--Sufficient clearance has been allowed between the shaft and journal to allow free running without overheating

V. Seize--One surface adhering to another because of heat and pressure

Example: A piston will seize in a cylinder because of lack of lubrication or overexpansion due to excessive heat

W. Shrink fit--Exceptionally tight fit achieved by heating and/or cooling of parts

(NOTE: The outer part is heated above its normal operating temperature or the inner part chilled below its normal operating temperature and assembled in this condition.)

X. Valve lapping--Process of mating the valve seat and valve face

(NOTE: This is performed with the aid of an abrasive.)

Y. Valve grinding--Process of refacing the valve and seat to manufacturer's specifications

Z. Valve face--Angle surface of valve which mates with the seat to seal the chamber

AA. Valve head--Top of the large diametered valve end

BB. Valve margin--Space between valve face and head

INFORMATION SHEET

CC. Valve stem--Long portion of valve which reciprocates in valve guide

DD. Valve seat--Angle surface in engine block or head which provides mating surface for valve face

EE. Valve clearance--Distance between valve stem and tappet at lowest tappet position

II. Causes of engine problems

A. Allowing dirt to get into the engine

B. Failure to check crankcase oil level often enough and letting engine run low on oil

C. Overloading the engine so that it works too hard

D. Running the engine too fast

E. Failure to properly store the engine during the off season

III. Parts of piston and connecting rod assembly (Transparencies 1 and 2)

A. Land

B. Piston head

C. Piston pin (wrist pin)

D. Skirt

E. Pin hole

F. Oil ring groove

G. Compression and scraper ring groove

H. Ring side clearance

I. Skirt clearance

J. Retaining ring

K. Connecting rod

L. Connecting rod bearing cap

M. Connecting rod bolts, washers, and nuts

INFORMATION SHEET

IV. Parts of crankshaft assembly (Transparency 3)

  A. Main bearing journals

  B. Crankpin

   (NOTE: This is the connecting rod bearing journal.)

  C. Counterweights

V. Parts of a multi-piece crankshaft assembly (Transparency 4)

  A. Connecting rods

  B. Crankpin

  C. Crankpin nuts

  D. Pinion shaft

  E. Lock plate

  F. Bearing rollers and retainers

  G. Sprocket shaft

  H. Crank wheels

VI. Parts of the valve train (Transparency 5)

  A. Margin

  B. Seat

  C. Stem

  D. Face

  E. Retainer

  F. Adjusting nut

  G. Tappet guide

  H. Cam

  I. Head

  J. Valve guide

  K. Valve spring

INFORMATION SHEET

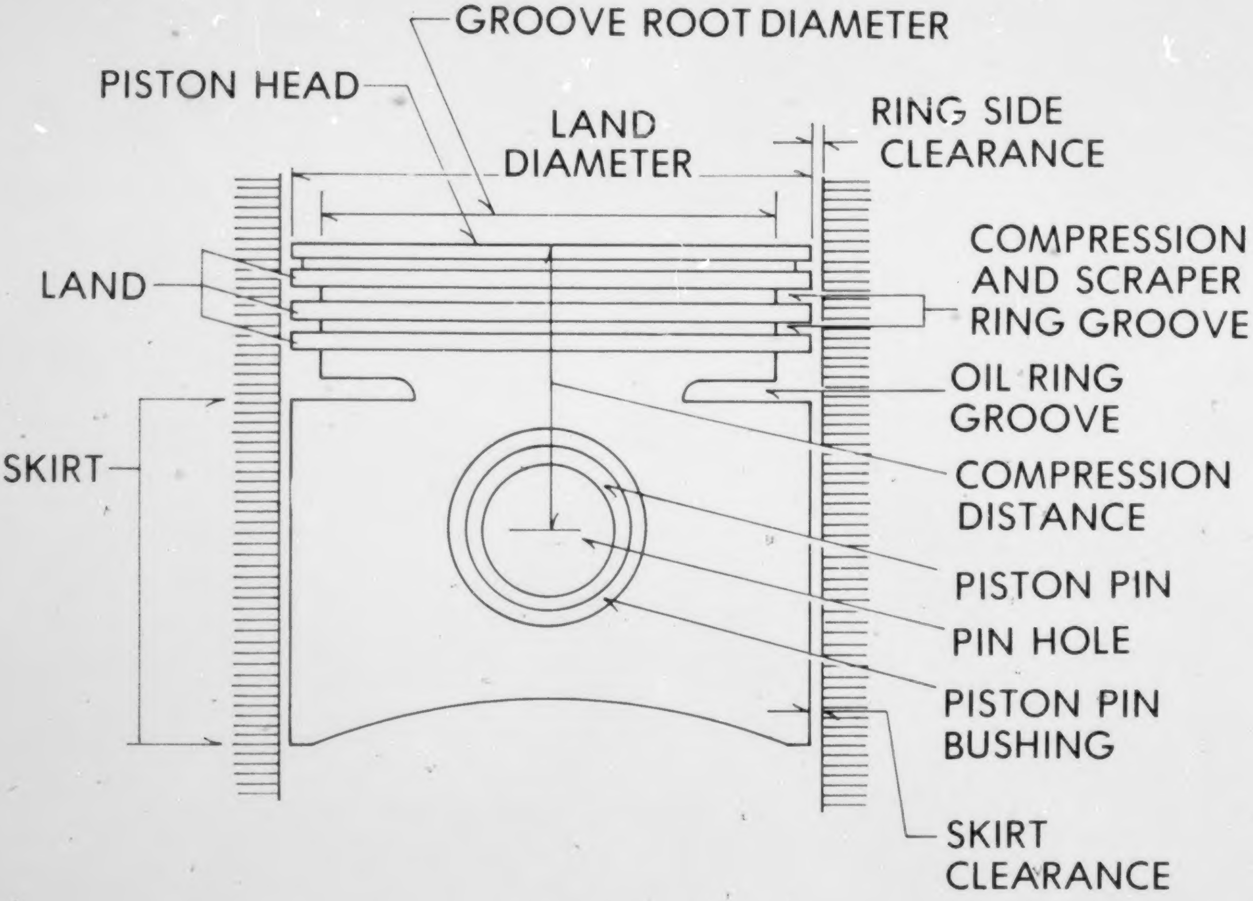
L. Clearance

M. Locknut

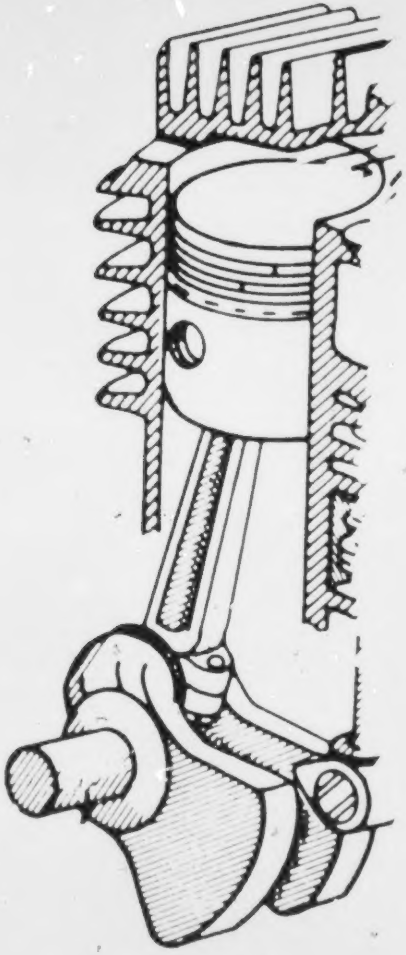
N. Tappet

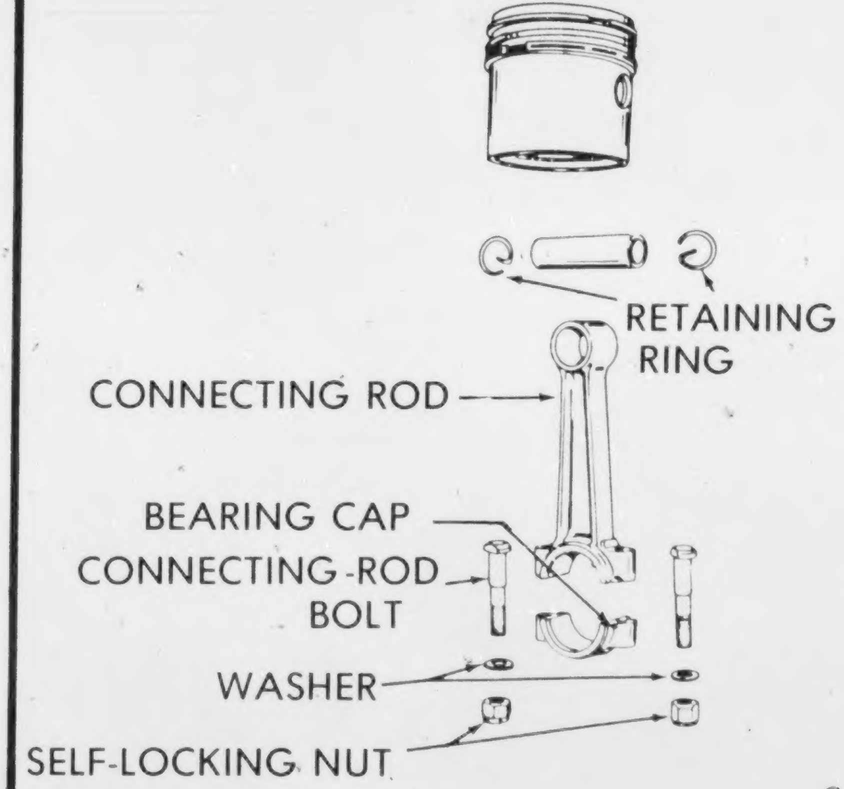
O. Shaft

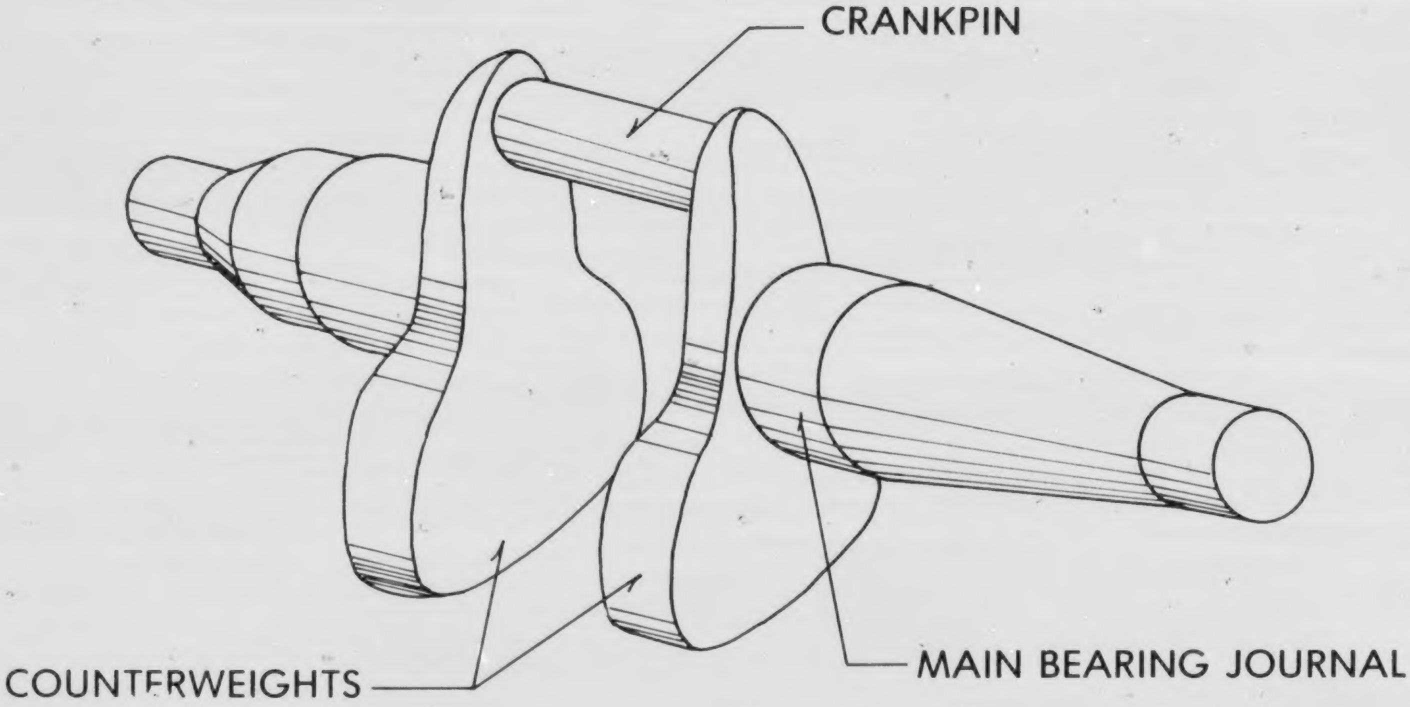
PISTON AND ROD ASSEMBLY


GROOVE ROOT DIAMETER
PISTON HEAD
LAND DIAMETER
RING SIDE CLEARANCE
COMPRESSION AND SCRAPER RING GROOVE
LAND
OIL RING GROOVE
SKIRT
COMPRESSION DISTANCE
PISTON PIN
PIN HOLE
PISTON PIN BUSHING
SKIRT CLEARANCE

CONNECTING ROD ASSEMBLY

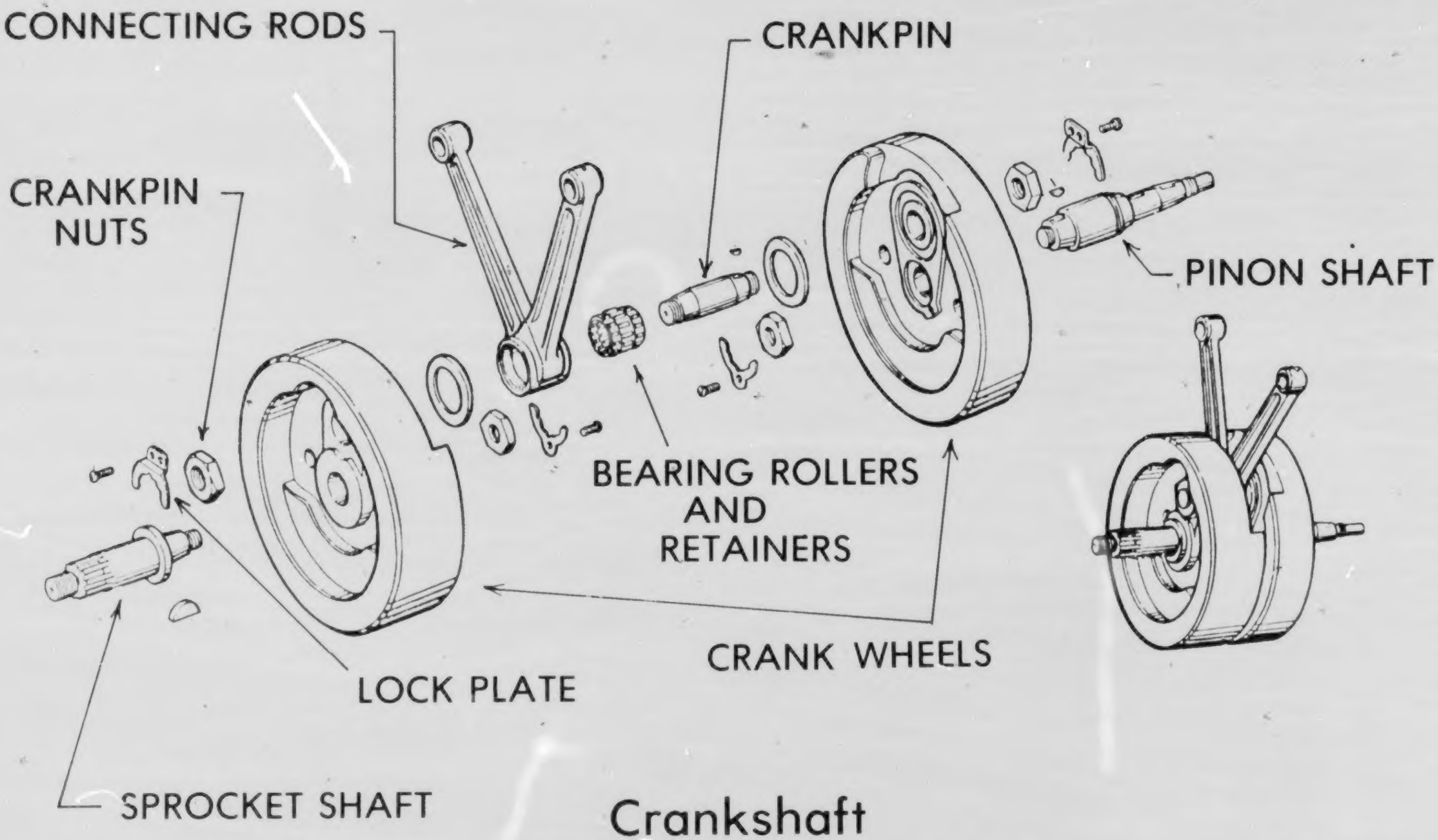



RETAINING RING
CONNECTING ROD
BEARING CAP
CONNECTING-ROD BOLT
WASHER
SELF-LOCKING NUT


CRANKPIN
COUNTERWEIGHTS
MAIN BEARING JOURNAL

CRANKSHAFT ASSEMBLY

MULTI-PIECE CRANKSHAFT ASSEMBLY



CONNECTING RODS

CRANKPIN

CRANKPIN NUTS

PINON SHAFT

BEARING ROLLERS AND RETAINERS

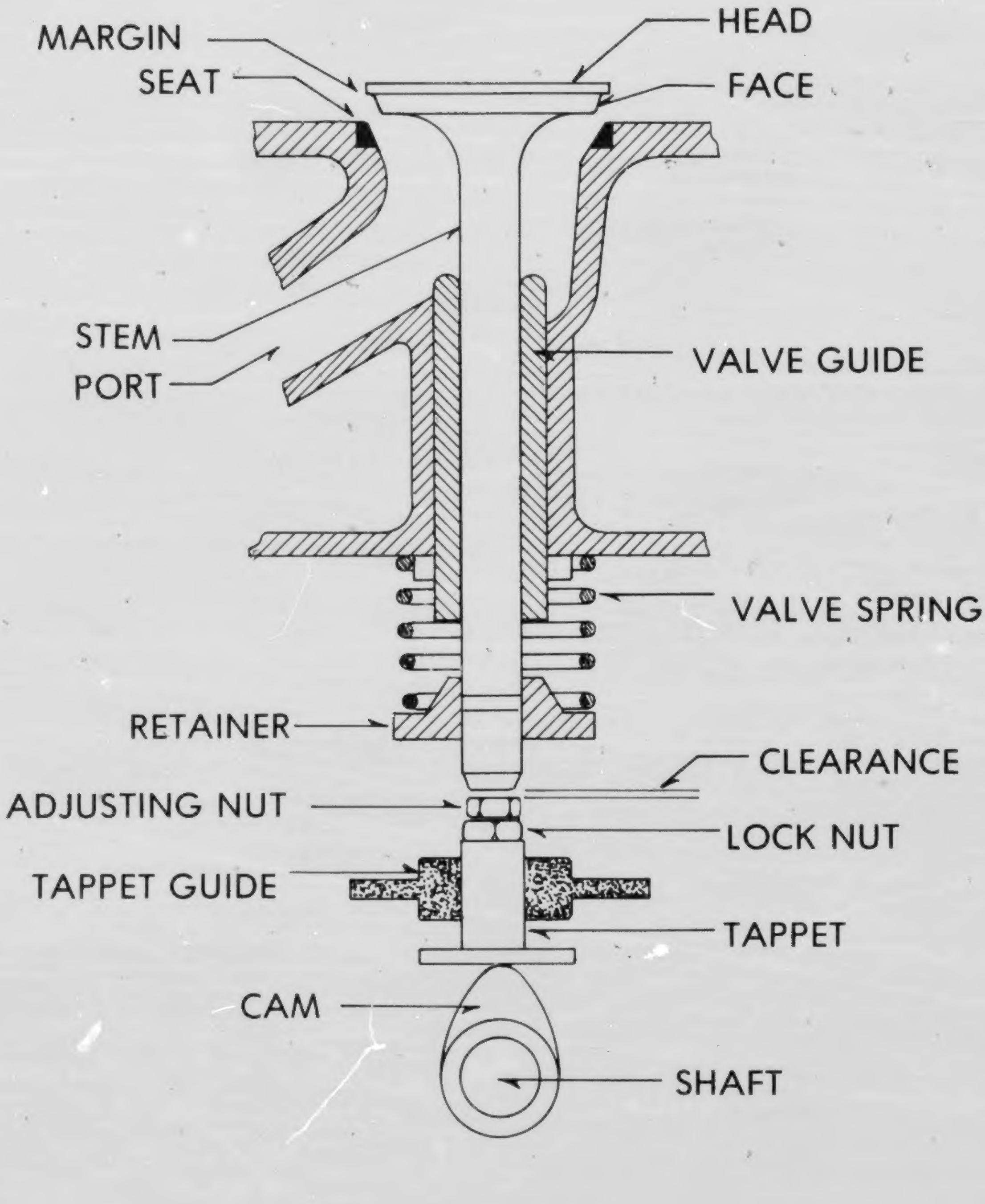
CRANK WHEELS

LOCK PLATE

SPROCKET SHAFT

Crankshaft

VALVE TRAIN


MARGIN
SEAT
HEAD
FACE
STEM
PORT
VALVE GUIDE
VALVE SPRING
RETAINER
CLEARANCE
ADJUSTING NUT
LOCK NUT
TAPPET GUIDE
TAPPET
CAM
SHAFT

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VII

JOB SHEET #1-DISASSEMBLE A FOUR-STROKE CYCLE ENGINE

I. Tools and materials

- A. Hand tool assortment
- B. Flywheel wrench
- C. Flywheel holder
- D. Flywheel puller
- E. Valve spring compressor
- F. Engine stand
- G. Shop towels
- H. Cleaning solvent
- I. Safety glasses

II. Procedure

- A. Disconnect spark plug cable and remove spark plug
- B. Disconnect all belts, chains, remote throttle control linkage, and exhaust system if attached to implement or vehicle
- C. Remove engine from implement or vehicle

  (NOTE: If remote fuel tank is used disconnect fuel lines from engine.)
- D. Mount engine on suitable stand

  (NOTE: Some smaller engines are easier to disassemble on a work bench.)
- E. Drain oil from crankcase
- F. Remove starter unit
- G. Remove air cleaner and its mounting bracket
- H. Remove exhaust pipe and muffler
- I. Remove carburetor and intake manifold

  (NOTE: Be sure to note throttle and choke connections; it might help to sketch the linkage.)

JOB SHEET #1

J. Remove air shroud, blower housing baffles, and fuel tank

(CAUTION: Position tank so fuel will not leak out.)

K. Remove the flywheel

(NOTE: Always use the right puller.)

L. Remove all magneto components

M. Clean all outside surfaces of the engine using an approved solvent

(CAUTION: Never use solvents that burn easily nor those which may be harmful to humans.)

(NOTE: As parts are cleaned and dried lay them out in an organized pattern on the clean workbench.)

N. Remove the cylinder head

(NOTE: On engines with overhead camshafts refer to appropriate service manual for exact procedures.)

O. Mark bolts so different length bolts will be returned to the proper location (Figure 1)

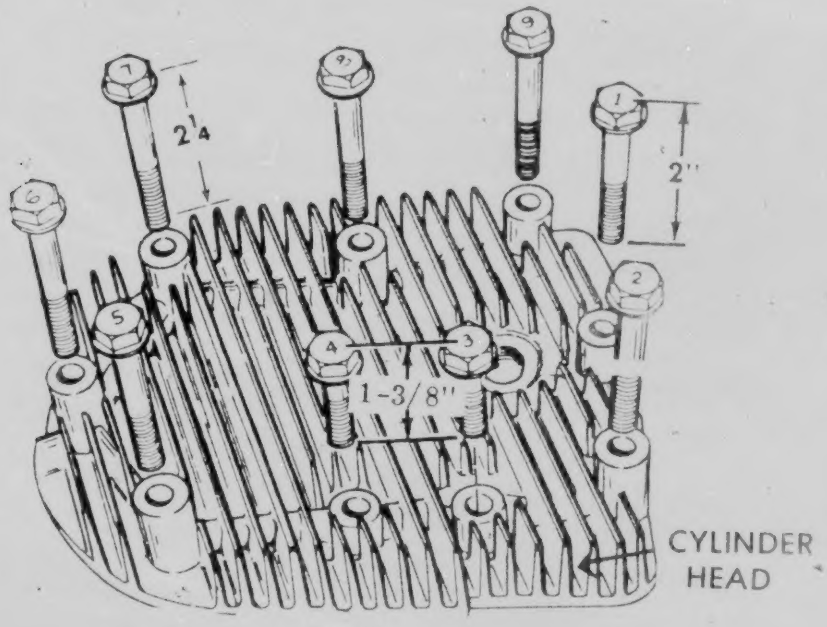


FIGURE 1

JOB SHEET #1

P. Remove valve cover

Q. Install valve spring compressor (Figure 2)

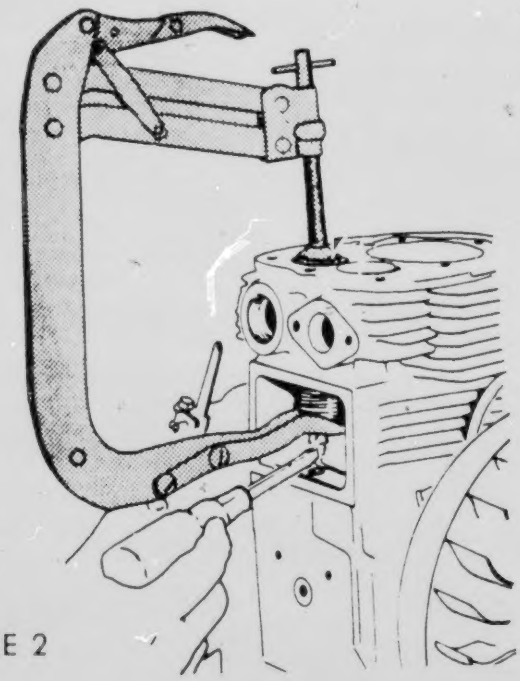


FIGURE 2

R. Compress valve spring

S. Remove spring keepers and collars

T. Remove tension on valve spring

U. Remove spring compressor

V. Remove valve

(NOTE: Be sure and check for roughness at valve lock groove to prevent guide damage during removal.)

W. Remove spring

(NOTE: Mark springs as exhaust or intake for reassembly.)

X. Repeat steps "Q" through "W" for other valve(s)

JOB SHEET #1

Y. Remove piston assembly

(NOTE: Refer to appropriate service manuals for exact procedures on engines with removable cylinders.)

1. Rotate crankshaft until piston is at bottom of cylinder
2. Remove oil sump

   (CAUTION: Be sure crankshaft is clean before sump is removed.)

   (NOTE: Some engines have removable side plates instead of removable oil sumps.)
3. Remove oil slinger or pump, camshaft, and tappets

   (NOTE: Mark tappets for replacement.)
4. Feel upper cylinder with finger to check for a ridge
5. Remove ridge with ridge cutter (Figure 3)

   (NOTE: Refer to ridge cutter installation and cutting procedures.)

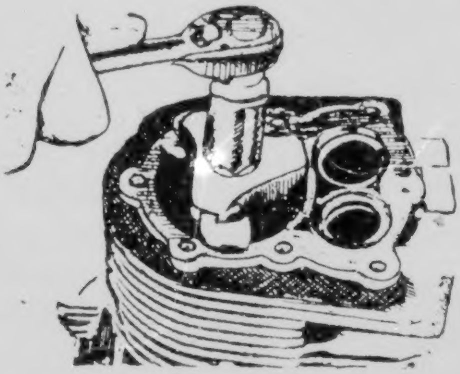


FIGURE 3

JOB SHEET #1

6. Bend tang away from connecting rod bolts (Figure 4)

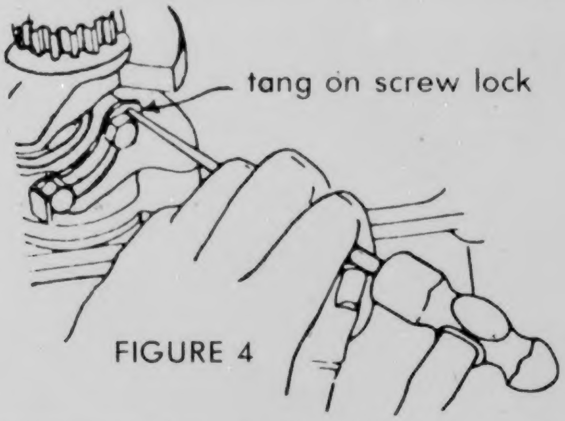

tang on screw lock

FIGURE 4

7. Remove connecting rod bolts (Figure 5)

(NOTE: Notice location of marks on bearing cap and rod so they can be returned to correct location.)

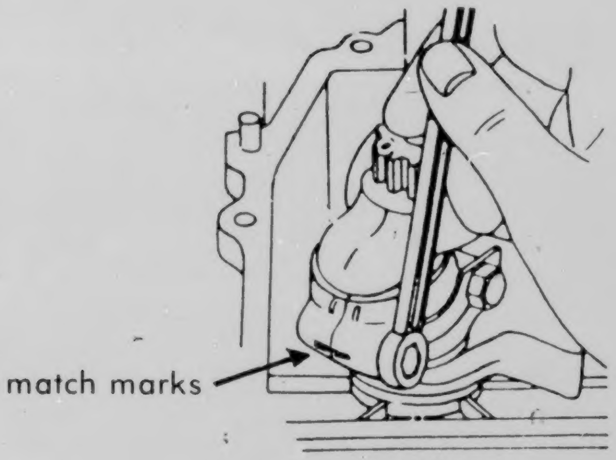

match marks

FIGURE 5

JOB SHEET #1

8. Remove piston and rod (Figure 6)

(NOTE: Scribe across piston and block so piston can be returned in its original direction.)

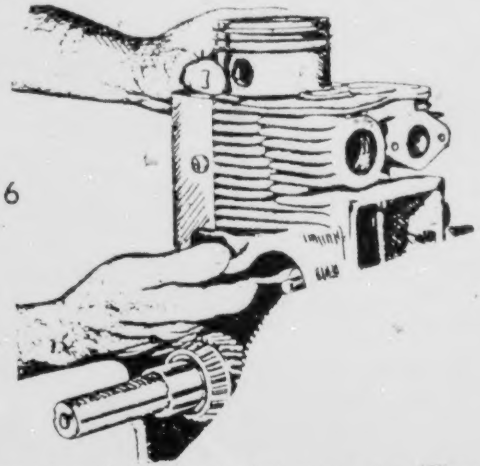


FIGURE 6

Z. Remove rings from piston using the correct ring expander (Figure 7)

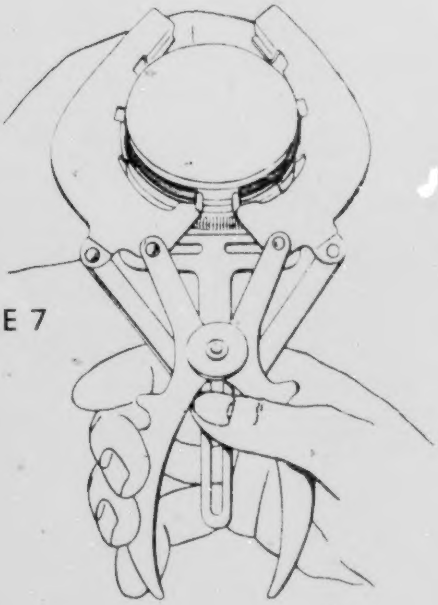


FIGURE 7

JOB SHEET #1

AA. Remove piston pin locks (Figure 8)

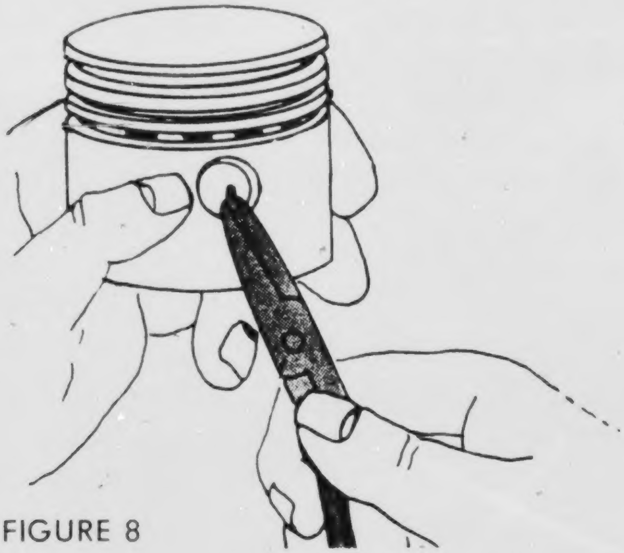


FIGURE 8

BB. Remove piston pin (Figure 9)

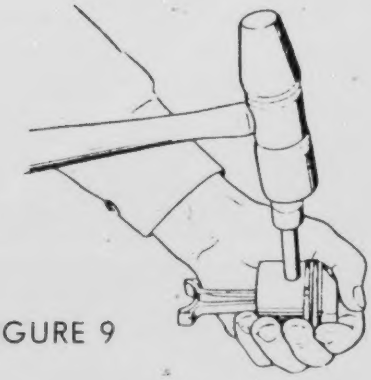


FIGURE 9

JOB SHEET #1

CC. Remove crankshaft

1. Remove crankshaft retainers if any are used

2. Remove crankshaft from block and bearing plate (Figures 10 and 11)

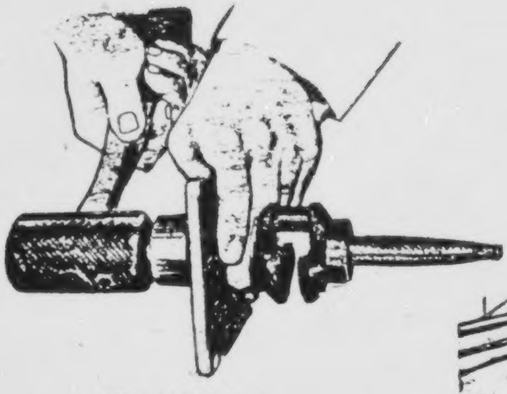


FIGURE 10

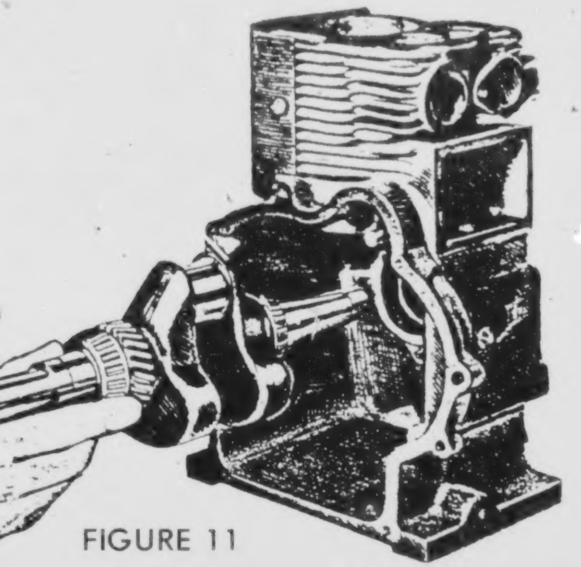


FIGURE 11

(NOTE: A gentle pull on engines with tapered roller bearings will usually work. On engines with sleeve inserts or cast in bearings, gentle taps with a soft mallet are often required.)

DD. Clean all parts and dry for inspection and measurement

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VII

JOB SHEET #2--INSPECT AND SERVICE A CYLINDER

I. Tools and materials

- A. Measuring instruments
- B. Deglazing tool
- C. Portable drill
- D. Cylinder vise support
- E. Light oil 5-10 weight
- F. Shop towels
- G. Hand tool assortment
- H. Hone
- I. Boring bar
- J. Safety glasses

II. Procedure

- A. Inspect
  1. Examine for cracks, stripped threads, broken fins, and scored and damaged cylinder walls

     (NOTE: Any of these may require replacement of the cylinder.)

  2. Repair any stripped threads using a Heli-coil
     - a. Drill out worn thread
     - b. Tap hole with Heli-coil tap
     - c. Install Heli-coil insert to bring hole back to original thread (Figure 1)

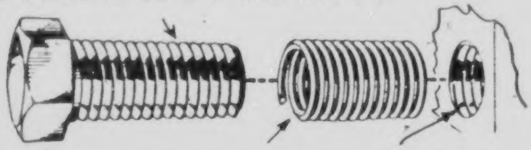


FIGURE 1

JOB SHEET #2

B. Measure ring travels

1. Take measurements at top, center, and bottom of ring travels both parallel and at right angles to the crankshaft (Figure 2)

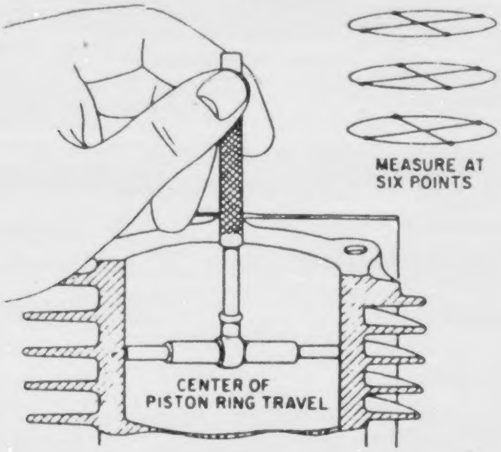


FIGURE 2

2. Check to see if measurements are within manufacturer's specifications

C. Deglaze cylinder if it falls within manufacturer's specified tolerances

(NOTE: Refer to appropriate service manual for exact deglazing procedures.)

1. Clean cylinder with hot soapy water

   (NOTE: Do not use gasoline, kerosene, or solvents for this cleaning job.)

2. Dry cylinder

D. Bore cylinders

(NOTE: Check manufacturer's specifications for equipment needed. If engine does not meet manufacturer's specifications for standard ring replacement, it should be bored or honed.)

1. Determine cylinder wall type

   (NOTE: Some cylinders cannot be rebored. Chrome plated aluminum cylinders, for instance, must be discarded if worn or damaged.)

JOB SHEET #2

2. Hone boring to oversize

(NOTE: Boring is done in .010 increments. If first .010 leaves nicks or scrapes unrepaired, go to .020 over standard.)

a. Install cylinder in vise or cylinder support

b. Insert hone into cylinder

(NOTE: Be sure and use correct stone.)

c. Start drill or drill press

d. Raise and lower hone in cylinder while it rotates (Figure 3)

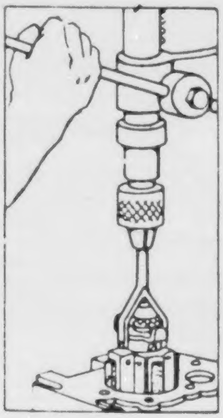


FIGURE 3

e. Stop periodically to measure progress

f. Stop boring when you are within .002 in. of desired diameter

g. Change to finishing stones and finish honing to crosshatch pattern

h. Clean cylinders

3. Bore to oversize with a boring bar

a. Secure block to boring bar base

b. Set cutter depth (Figure 4)

(NOTE: Refer to boring bar instruction manual for exact procedure. You should leave approximately .0025 for finish honing.)

JOB SHEET #2

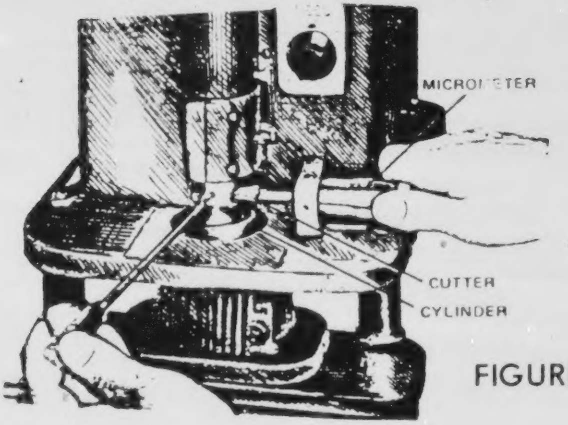

MICROMETER
CUTTER
CYLINDER

FIGURE 4

c. Start boring bar

d. Bore complete cylinder length

e. Retract boring arm

f. Remove cylinder

(NOTE: Check to make sure correct bore was made. Use same technique as in original check.)

g. Finish hone cylinder

h. Clean cylinder

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VII

JOB SHEET #3--INSPECT AND SERVICE THE PISTON, RINGS, AND CONNECTING ROD

I. Tools and materials

   A. Outside micrometer

   B. Telescoping gauge

   C. Ring groove cleaner

   D. Feeler gauges

   E. Ring expander

   F. Manufacturer's engine manual

   G. Hand tool assortment

   H. Safety glasses

II. Procedure

   A. Check piston visually for scoring wear spots and deformities

   (NOTE: Discard the piston and replace with a new one if you feel it has damage that will effect engine performance.)

   B. Secure piston in vise

   C. Remove rings using ring expander (Figure 1)

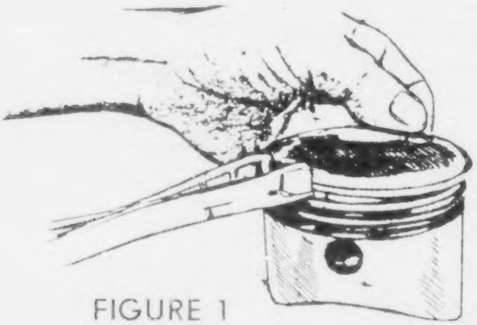


FIGURE 1

JOB SHEET #3

D. Clean carbon from ring grooves with special cleaner (Figure 2)

(NOTE: Be sure and do not alter the groove size.)

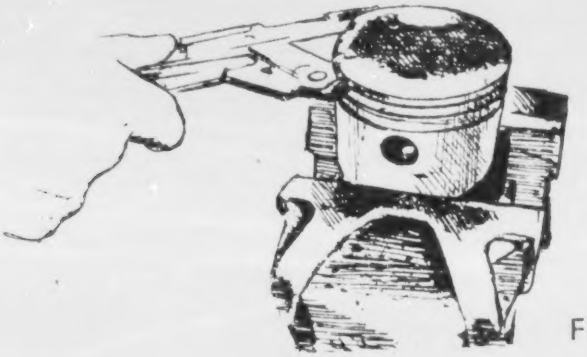


FIGURE 2

E. Take piston measurement at the head and skirt (Figures 3 and 4)

(NOTE: Take four measurements, two at right angle to pin opening and two parallel.)

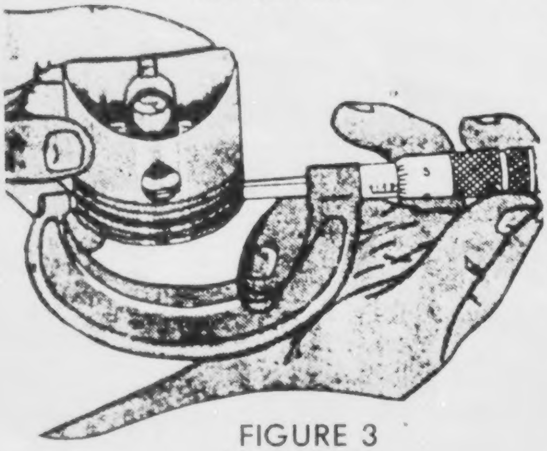


FIGURE 3

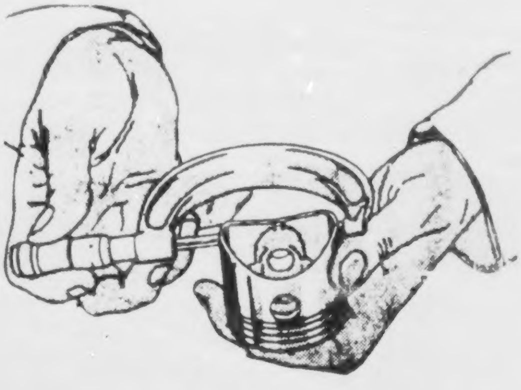


FIGURE 4

F. Compare measurements to manufacturer's specifications

(NOTE: Discard piston if it does not fall within manufacturer's specifications.)

G. Check for ring groove wear

1. Install new ring using ring expander

JOB SHEET #3

2. Insert feeler gauge between ring and groove (Figure 5)

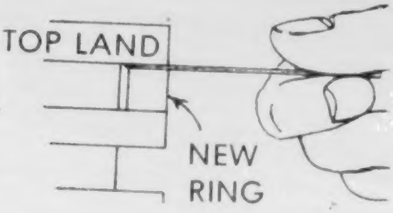


FIGURE 5

3. Compare with the manufacturer's specifications

   (NOTE: Discard piston if measurements do not fall within manufacturer's tolerances.)

4. Repeat for remaining ring grooves

   (NOTE: On some multi-cylinder engines the manufacturers recommend piston balancing. Refer to appropriate service manual.)

H. Service and inspect pin and connecting rod

   1. Remove pin retainers (Figure 6)

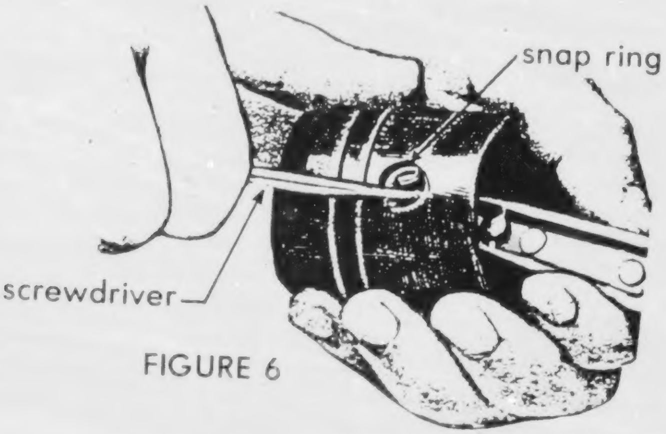


FIGURE 6

JOB SHEET #3

2. Drive out piston pin with soft hammer and dowel (Figure 7)

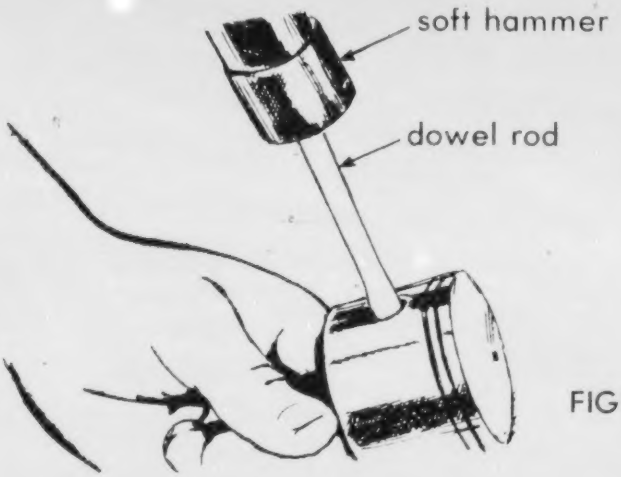


FIGURE 7

3. Measure pin diameter using micrometer

4. Measure piston boss with small hole gauge

5. Measure hole gauge with micrometer

6. Subtract pin measurement from boss measurement

7. Compare to manufacturer's specifications

   (NOTE: Some manufacturers recommend replacement if tolerances are not within specifications; others recommend boring piston bosses to oversize and using a larger pin. Some rods use replaceable bearings. Refer to appropriate service manual for exact procedures.)

8. Check rod for straightness

   (NOTE: Big and small bearing holes must be parallel. Straighten or replace as necessary. Some multi-cylinder engines require rod balancing. Refer to appropriate service manual.)

9. Connect rod cap to connecting rod

   (NOTE: Be sure alignment marks on cap and rod are mated before tightening cap screws. Refer to appropriate service manual for torque.)

JOB SHEET #3

10. Measure inside diameter of crankpin opening in two places 180° apart (Figure 8)

    (NOTE: On rods with bearing inserts use same procedure with insert installed.)

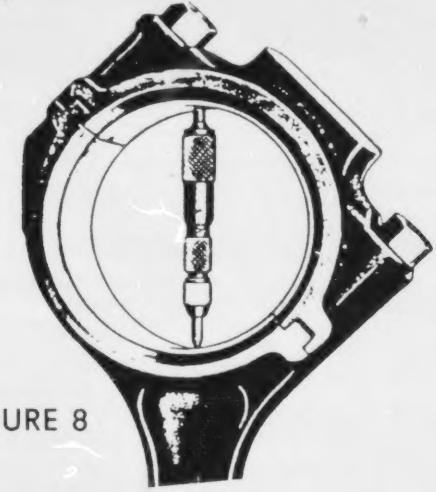


FIGURE 8

11. Compare reading to manufacturer's specification

    (NOTE: If out-of-roundness is found in your readings, discard rod and get a new one to replace it. On models with bearing inserts put in new bearings if manufacturer's specifications are not met or out-of-roundness is found.)

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VII

JOB SHEET #4--INSPECT AND SERVICE A CRANKSHAFT ASSEMBLY

I. Tools and materials

   A. Telescoping gauge

   B. Outside micrometer

   C. Seal removal tools

   D. Seal installation tools

   E. Bearing pullers

   F. Bearing installation tools

   G. Hand tool assortment

   H. Safety glasses

II. Procedure

   A. Inspect crankshaft for scoring, straightness, damaged keyway, damaged breaker flat, battered threads or worn timing gear teeth

   B. Discard if beyond repair

   (NOTE: Some crankshafts can be straightened and battered threads can be repaired with a thread file or thread chaser.)

   C. Using an outside micrometer check main bearing journals and crankpin journal for out-of-roundness and taper (Figure 1)

   (NOTE: Check two or three places up and down the journal as well as two places around it.)

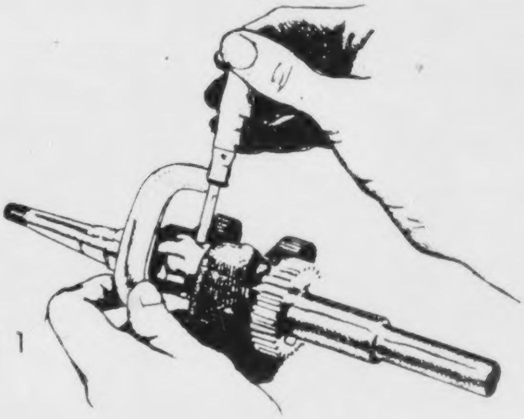


FIGURE 1

JOB SHEET #4

D. Compare measurements to manufacturer's specifications

(NOTE: On some engines the crankshaft is separable and journals can be replaced. Some expensive crankshafts can be reground to a standard undersize. Most crankshafts should be replaced if they do not fall within specifications.)

E. Check and service main bearings and seals

1. Check seals
    a. Visually check for lip deterioration or wear
    b. Remove damaged seals (Figure 2)

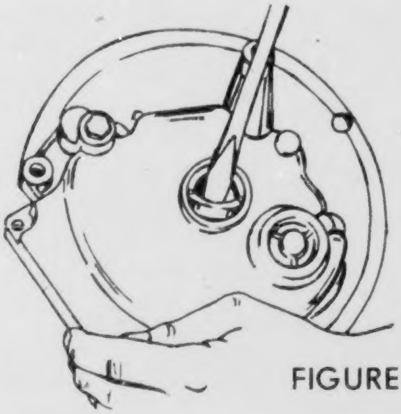


FIGURE 2

2. Inspect anti-friction bearings
    a. Clean bearings with solvent
    b. Visually check for pitted or damaged rollers
    c. Spin bearings and look and listen for deformities

    (CAUTION: Do not spin bearings with compressed air.)

JOB SHEET #4

d. Remove worn or damaged bearings (Figure 3)

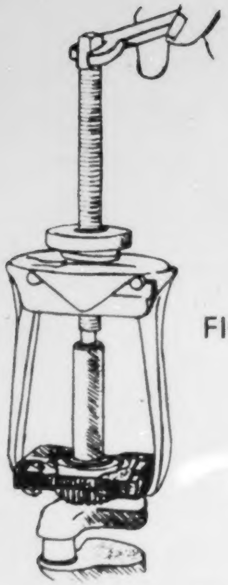


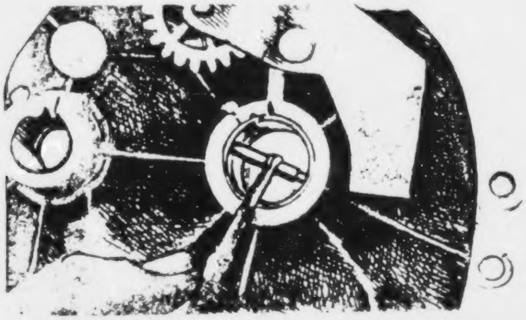
FIGURE 3

e. Replace with new bearings if needed

3. Inspect and repair bushings

a. Measure inside bearing diameter with telescoping gauge (Figure 4)

FIGURE 4



b. Measure gauge with micrometer

c. Compare to manufacturer's specifications

JOB SHEET #4

d. Repair damaged bearing

(NOTE: Some engines have cast in sleeves for bearings and are not repairable. Replacing the housing is the only repair.)

1) Drive out worn bearing (Figure 5)

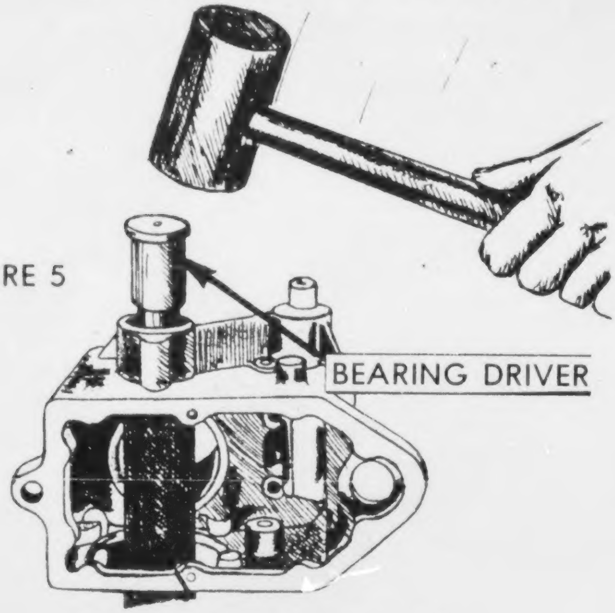

BEARING DRIVER

FIGURE 5

2) Replace with new bearing

e. Put in with new seals (Figure 6)

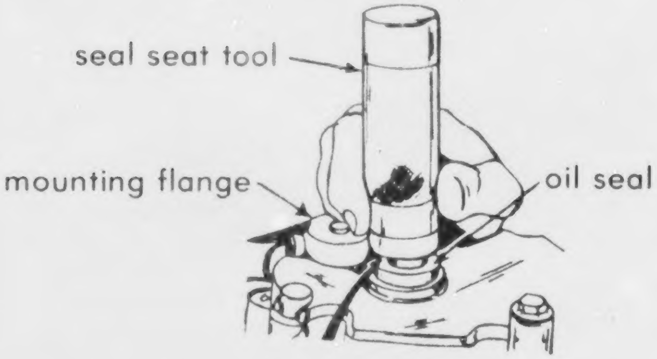

seal seat tool
mounting flange
oil seal

FIGURE 6

(NOTE: This may require special tools. Consult appropriate service manual.)

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VII

JOB SHEET #5--SERVICE A MULTI-PIECE CRANKSHAFT ASSEMBLY

I. Tools and materials

- A. Hand tool assortment
- B. Dial indicators
- C. Inside micrometer
- D. Outside micrometer
- E. Bearing puller
- F. Lathe or other suitable centering device
- G. Vise
- H. Solvent and brush or rags
- I. Soft hammer
- J. Thickness gauge
- K. Safety glasses

II. Procedure

A. Disassemble engine to expose crankshaft

(NOTE: Use appropriate job sheets and service manuals.)

B. Remove crankshaft assembly from engine

C. Disassemble crankshaft assembly

1. Place crankshaft vertically in a vise

(NOTE: Use wood blocks or jaw protectors to keep from damaging the crankshaft.)

JOB SHEET #5

2. Remove all bearings from the shaft (Figure 1)

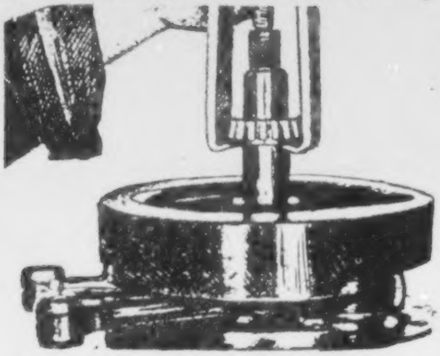


FIGURE 1

3. Separate crank throws or wheel

   a. Remove locking screws, plates, and nuts

   b. Tap outer rim of wheel to loosen with soft hammer

   c. Remove upper crank wheel (Figure 2)

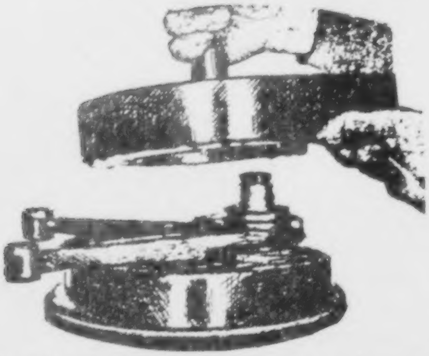


FIGURE 2

4. Hold bearings while pulling connecting rods off (Figure 3)

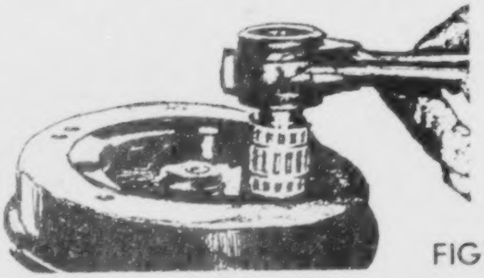


FIGURE 3

JOB SHEET #5

5. Remove bearings (Figure 4)

   (NOTE: Keep the bearings assembled as a set.)

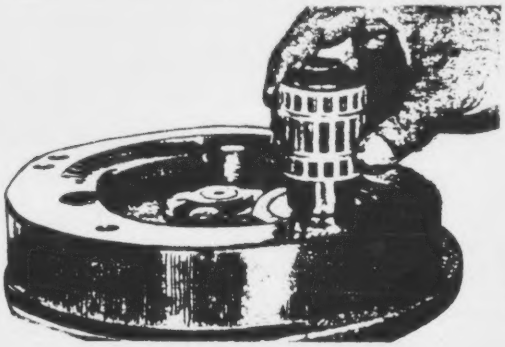


FIGURE 4

6. Remove remaining lock plate screw, lock plate, and crankpin nut

7. Tap crank wheel with soft hammer

8. Press out crankpin

D. Inspect parts

   1. Clean all parts in solvent

   2. Dry parts

   3. Check crankpin for wear with micrometer

      (NOTE: Replace if not within manufacturer's specified limits.)

   4. Check flywheel washers for wear

      (NOTE: Replace if any wear is evident.)

   5. Inspect connecting rod big end bearing surfaces with inside micrometer

      (NOTE: If they do not fall within manufacturer's specifications, replace with new rods, bearings, and crankpin.)

E. Fit rod bearings

   1. Fit rollers into races

      (NOTE: Any size could be used; all parts must be free of oil.)

JOB SHEET #5

2. Position assembled bearings into rods

3. Drop crankpin through hole in rod

   (NOTE: Plug fit is achieved when pin drops through hole of its own weight. Try different size rollers until this fit is obtained.)

4. Check overall width of roller retainer assembly

   (NOTE: It must be less than female rod big end width.)

F. Reassemble crankshaft assembly

(NOTE: Reverse disassembly procedures.)

1. Check sideshake (Figure 5)

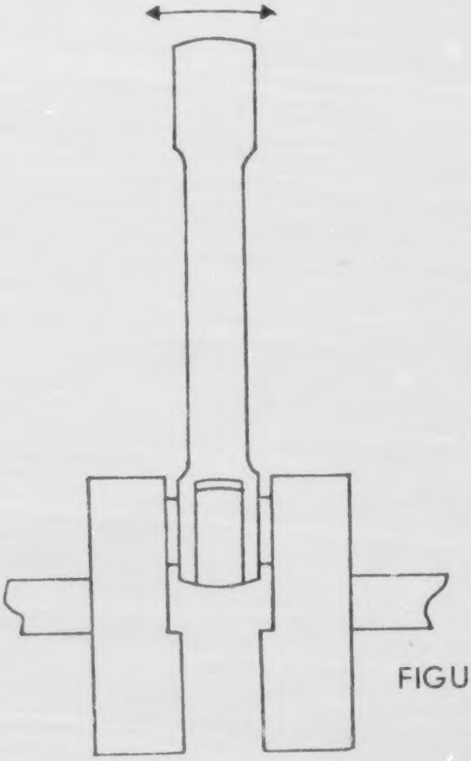


FIGURE 5

2. Compare to manufacturer's specifications

   (NOTE: Recheck bearing fit if specifications are not met.)

JOB SHEET #5

G. Align crankshaft assembly

1. Install crankshaft assembly in a lathe or other suitable centering device (Figure 6)

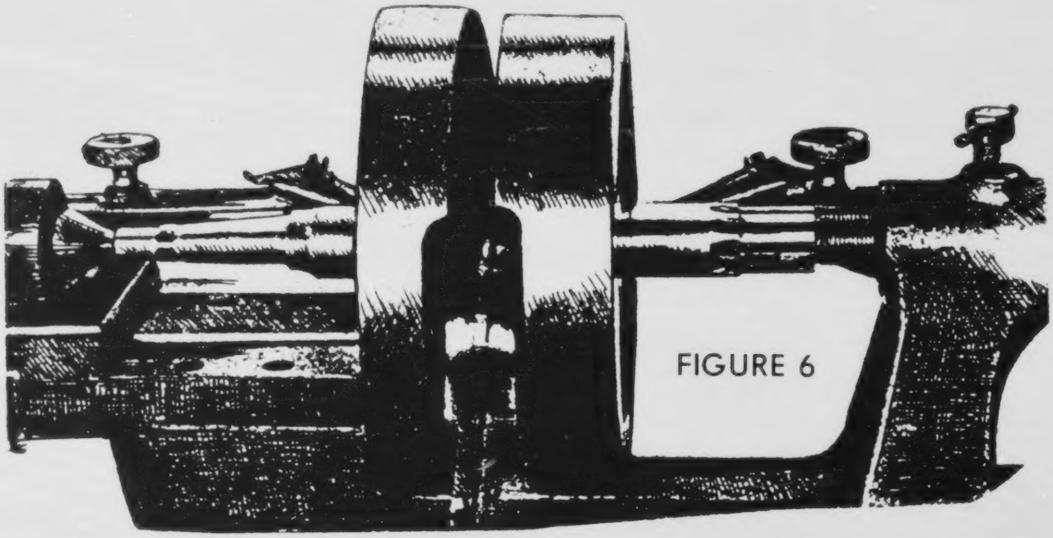


FIGURE 6

2. Mount dial indicators on bearing journals (Figure 7)

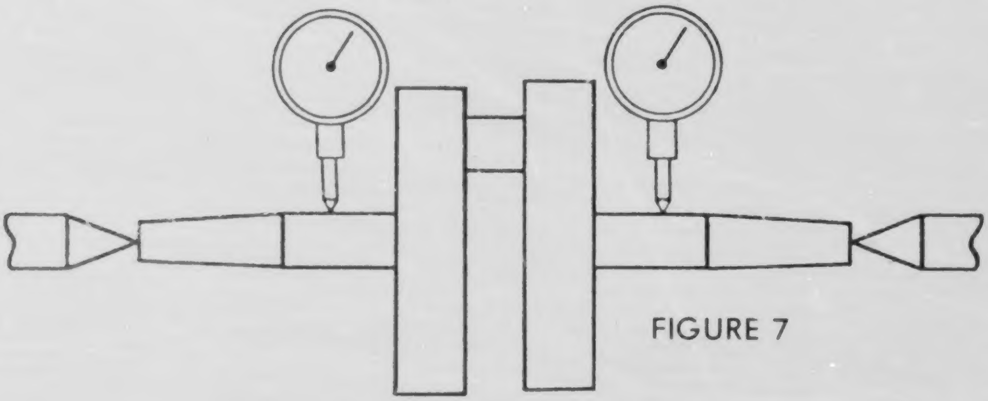


FIGURE 7

3. Rotate crankshaft and note indicator readings

4. Align shaft so maximum needle readings are the same

   a. Rotate the crank until sprocket side dial indicator reads its maximum

JOB SHEET #5

b. Mark crank wheel in line with dial indicator plunger

c. Remove crank from lathe

d. Tap crank wheel lightly with soft face hammer at mark (Figure 8)

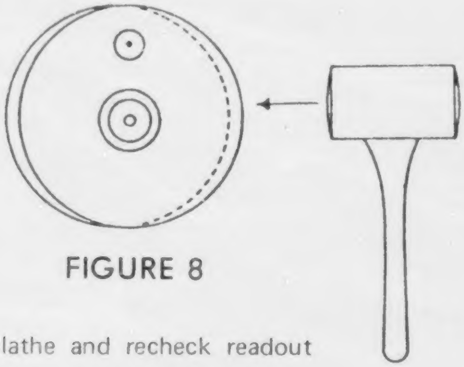


FIGURE 8

e. Reinstall in lathe and recheck readout

f. Repeat until readouts are the same

5. Adjust for pinch or spread

(NOTE: After the foregoing adjustment, the crank may still be pinched or spread. If the indicators show a maximum travel when crankpin is in toward the dial indicators, it is pinched; if maximum is shown when crankpin is away from indicators, the wheels are spread.)

a. Correct pinched wheels

1) Remove assembly from lathe

2) Drive wedge between wheels away from pin (Figure 9)

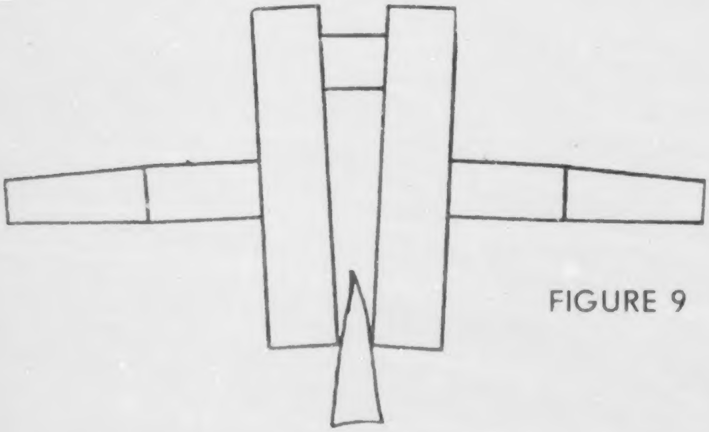


FIGURE 9

JOB SHEET #5

3) Replace in lathe and recheck runout

4) Repeat until manufacturer's specifications are met

b. Correct spread wheels

1) Remove crankshaft from lathe

2) Tap wheels opposite crankpin toward each other (Figure 10)

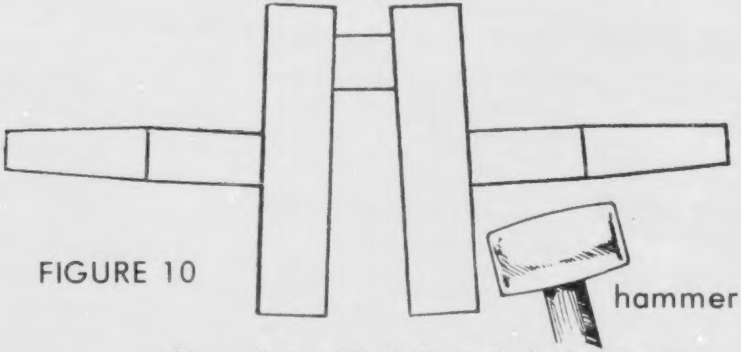


FIGURE 10

3) Replace in lathe and check runout

4) Repeat until manufacturer's specifications are met

H. Check side clearance

1. Place crankshaft in a vise
2. Torque to manufacturer's specifications
3. Insert thickness gauge (Figure 11)

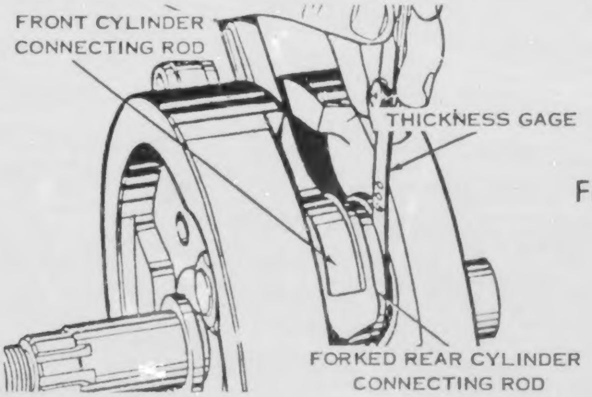

FRONT CYLINDER
CONNECTING ROD
THICKNESS GAGE
FORKED REAR CYLINDER
CONNECTING ROD

FIGURE 11

JOB SHEET #5

4. Compare to manufacturer's specifications

   (NOTE: If too much clearance exists, tighten crankpin nuts until specifications are met.)

I. Have instructor evaluate work

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VII

JOB SHEET #6-INSPECT AND SERVICE A VALVE ASSEMBLY

I. Tools and materials

- A. Valve seat grinding equipment
- B. Valve face grinding equipment
- C. Outside micrometer
- D. Telescoping gauge
- E. Valve spring tension tester
- F. Combination square
- G. Valve seat removal tools
- H. Valve seat driver
- I. Valve guide removal tools
- J. Valve guide reamers
- K. Hand tool assortment
- L. Mallet
- M. Square or scale
- N. Surface plate
- O. Safety glasses
- P. Appropriate service manual

II. Procedure

A. Inspect valves

1. Visually check valve for unusual or uneven wear, burned spots, pits, cracks, bent or burnt stems, and other damage

   (NOTE: Discard the valve if pits or cracks are too deep to dress off during regrinding or if stem is bent.)

JOB SHEET #6

2. Measure the valve stem with a micrometer (Figure 1)

   (NOTE: Discard the valve if it does not fall within manufacturer's specifications.)

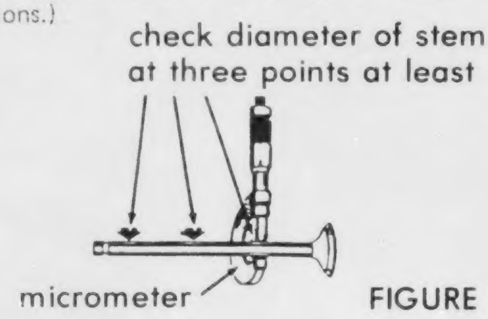

check diameter of stem
at three points at least
micrometer

FIGURE 1

3. Measure valve margin (Figure 2)

   (NOTE: Generally if margin is less than 1/64", valve is discarded; consult appropriate service manual for exact measurements.)

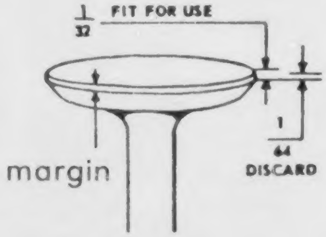

1/32 FIT FOR USE
margin
1/64 DISCARD

FIGURE 2

B. Repair valves

1. Determine correct angle and face width from appropriate service manual

2. Chuck valve in grinder

   (NOTE: Refer to grinder directions for proper procedure. Dress grinding wheel if necessary.)

JOB SHEET #6

3. Set grinder angle (Figure 3)

(NOTE: Consult grinder set up manual.)

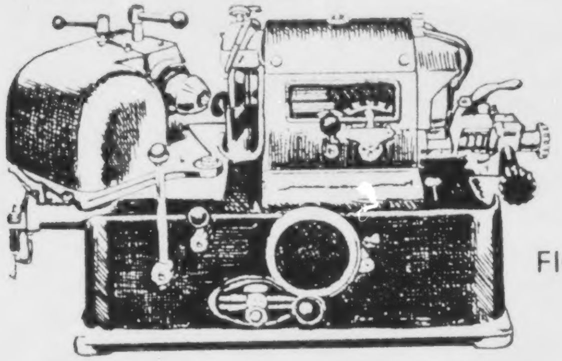


FIGURE 3

4. Grind valve

5. Measure margin and seating surface

(NOTE: Discard valve if suitable margin does not exist.)

C. Inspect valve guides

1. Measure inside diameter with dial indicator or telescoping gauge and micrometer or valve guide reject gauge (Figure 4)

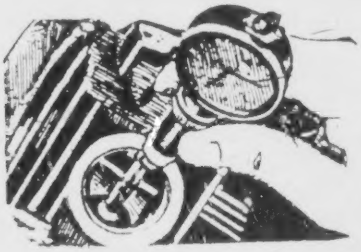


FIGURE 4

2. Compare to manufacturer's specifications

(NOTE: If measurement does not fall within manufacturer's specifications, repair or replace.)

D. Repair valve guides

(NOTE: There are two basic types of guides, those bored directly into the block and those using inserts.)

JOB SHEET #6

1. Replace insert type valve guides

   a. Remove worn guide (Figure 5)

   (NOTE: This may require a special tool; consult appropriate service manual.)

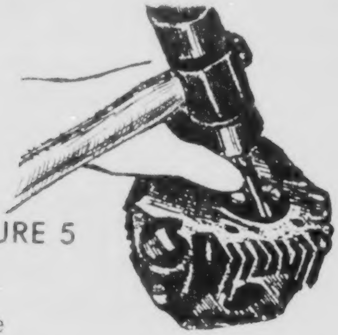


FIGURE 5

   b. Install new guide

   c. Ream to fit valve stem

   (NOTE: Be sure clearances between stem and guide fall within manufacturer's recommended tolerances.)

2. Repair guide without bushing inserts

   (NOTE: Many aluminum block engines have drilled guides with no inserts.)

   a. Ream to standard oversize

      1) Select appropriate reamer

      (NOTE: Reamer should oversize guide to appropriate size for oversized stems with manufacturer's recommended clearances.)

      2) Install reamer (Figure 6)

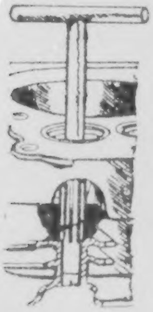


FIGURE 6

JOB SHEET #6

3) Rotate reamer while applying light downward pressure

4) Ream entire length of guide

5) Measure reamed guide with telescoping gauge and micrometer or dial indicator

b. Ream for guide insert

1) Select appropriate reamer

(NOTE: Your reamer needs to be large enough to allow for an insert to be pressed into the bore. The bore should be approximately .001 in. smaller than the insert.)

2) Ream guide

3) Install guide insert

4) Ream to standard size (Figure 7)

(NOTE: Reamer used here should put new insert to standard size with recommended clearances.)

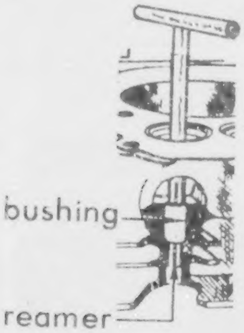


FIGURE 7

E. Inspect valve seats

(NOTE: Check to see if valve seat is machined into the head or if it is an insert.)

1. Visually check valve seats for cracking and pitting

JOB SHEET #6

2. Check seat width and angle (Figure 8)

(NOTE: Depth of valve seat and its width can tell you about the number of times it has been refaced.)

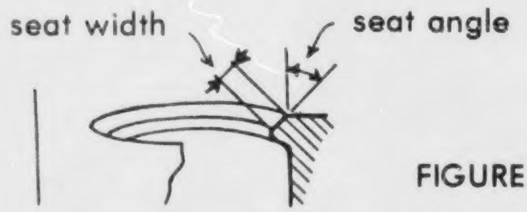

seat width
seat angle

FIGURE 8

VALVE SEAT DIMENSIONS

F. Repair or replace valve seats

1. Reface valve seats

a. Select appropriate refacing tools (Figures 9 and 10)

(NOTE: Drill motors and carborundum wheels or special cutters of the appropriate size will work.)

FIGURE 9

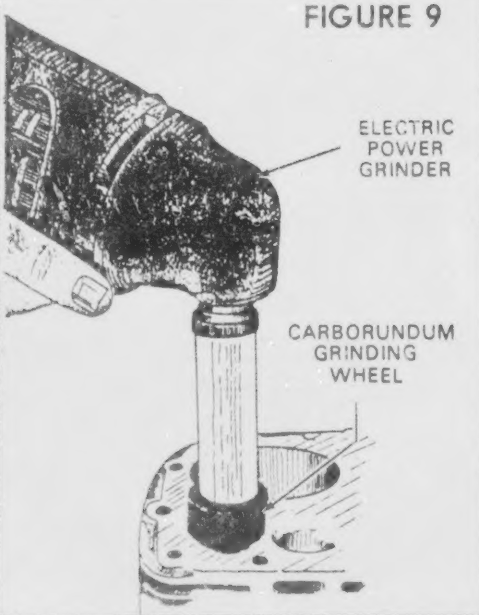
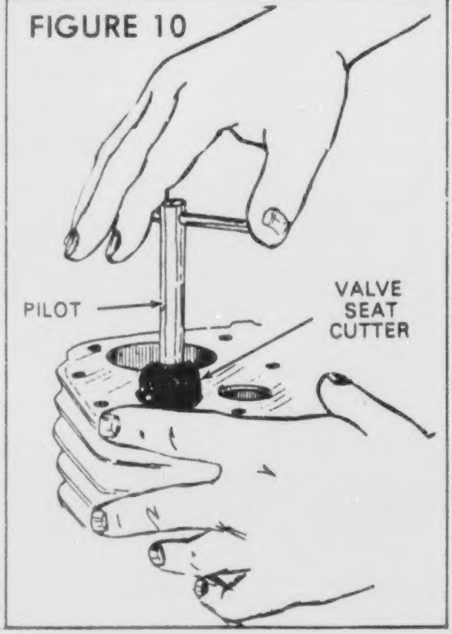

ELECTRIC
POWER
GRINDER
CARBORUNDUM
GRINDING
WHEEL

FIGURE 10


PILOT
VALVE
SEAT
CUTTER

JOB SHEET #6

b. Install pilot in guide

(NOTE: Guides should have been inspected or reconditioned to guarantee straightness.)

c. Install refacing tool

d. Start tool rotating

e. Cut all oxidation away

f. Check seat width

(NOTE: If width is over 1/16", narrow it down with a 15° to 30° wheel at the top and a 60° to 75° wheel at the bottom.)

2. Replace valve seats

a. Remove worn seat (Figures 11 and 12)

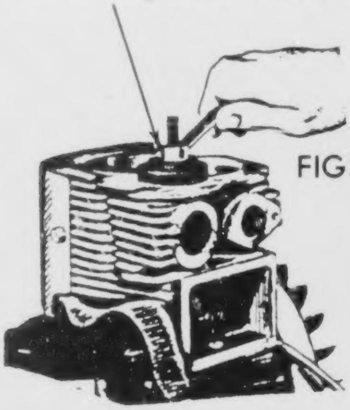

removing seat insert with puller

FIGURE 11

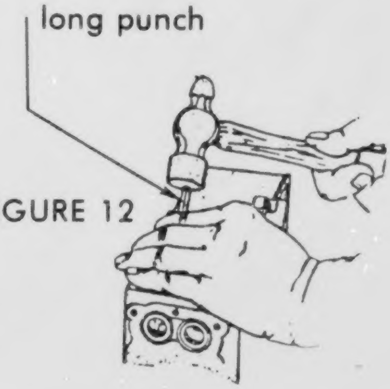


FIGURE 12

b. Place new seat in opening

(NOTE: It is often recommended that the new seat be chilled for at least one hour in a freezer.)

JOB SHEET #6

c. Install seat driving tool (Figure 13)

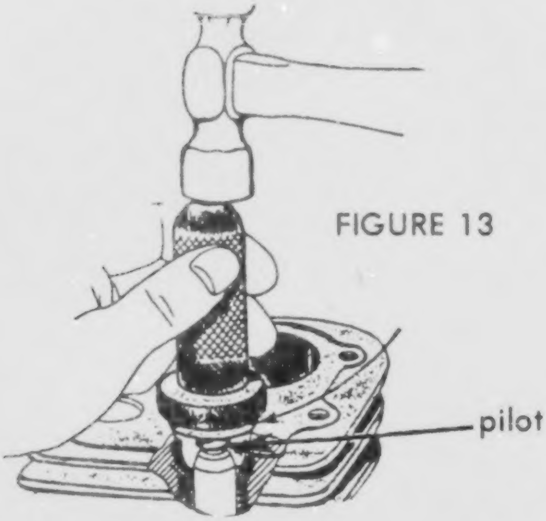


FIGURE 13

d. Tap tool to set new seat

e. Reface seat to recommended specifications

G. Inspect valve springs

1. Determine spring height using surface plate and scale or square (Figure 14)

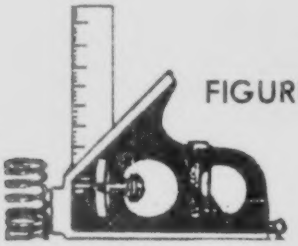


FIGURE 14

2. Compare to manufacturer's specifications

(NOTE: Discard if spring does not fall within tolerances.)

JOB SHEET #6

3. Check valve spring tension (Figure 15)

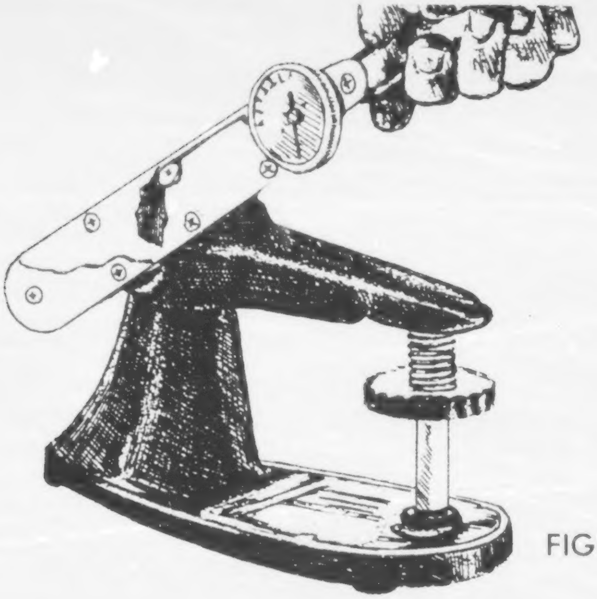


FIGURE 15

4. Compare to manufacturer's specifications

   (NOTE: Discard if manufacturer's specifications are not met.)

5. Check spring for straightness (Figure 16)

   (NOTE: Discard if spring is more than 3/16" out of square.)

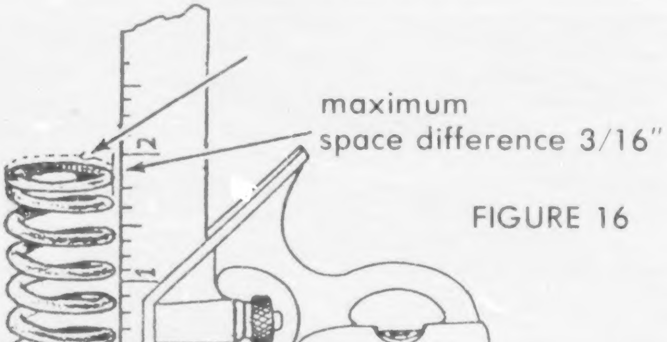

maximum
space difference 3/16"
2
1

FIGURE 16

JOB SHEET #6

H. Check camshaft

1. Measure bearing journals (Figure 17)

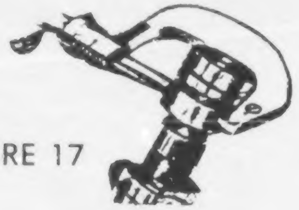


FIGURE 17

2. Measure inside bearing diameters
3. Subtract bearing diameter from journals and compare to manufacturer's specifications
4. Replace bearings if needed
5. Measure cam lobe and compare to manufacturer's specifications

   (NOTE: Discard if tappet or push rod adjustment will not compensate for deterioration.)

6. Check gear teeth

   (NOTE: Discard if teeth are damaged.)

I. Check push rods (if applicable)

1. Check for straightness

   (NOTE: Rolling them on a surface plate is a fairly accurate method.)

2. Check for nicked or damaged ends

J. Check rocker arm assembly (if applicable)

1. Check cam contact area
2. Measure shaft bore with telescoping gauge and micrometer or dial indicator (Figure 18)

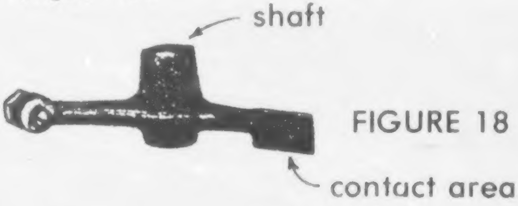


FIGURE 18

JOB SHEET #6

3. Inspect rocker arm shaft (Figure 19)

   (NOTE: Look for pitted or rough areas.)

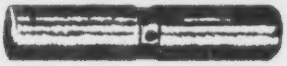


FIGURE 19

4. Measure rocker arm shaft with micrometer

5. Subtract rocker arm shaft reading from shaft bore reading

6. Compare to manufacturer's specifications

7. Repair if manufacturer's specifications are not met

   (NOTE: Repair usually involves driving out worn bushing and installing new. Consult appropriate service manual for exact procedure.)

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VII

JOB SHEET #7--REASSEMBLE A FOUR-STROKE CYCLE ENGINE

I. Tools and materials

A. Hand tool assortment

B. Gasket set for engines

C. Valve spring compressor

D. Ring compressor

E. Light engine oil (5-10 weight)

F. Ring expander (feeler gauge)

G. Shop towels

H. Manual for engine

I. Plastigage

J. Safety glasses

II. Procedure

A. Coat all metal to metal surfaces with light 5-10 weight oil before assembly

B. Install crankshaft in block

(NOTE: Wrap keyway to prevent cutting of seal with sharp edges.)

C. Assemble rod to piston with wrist pin (Figures 1 and 2)

(Caution: Be sure new lock rings are in their groove.)

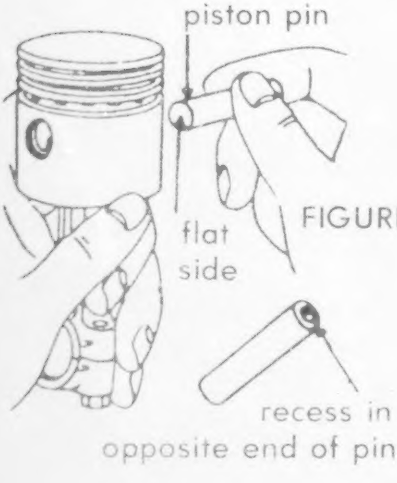

piston pin
flat side
recess in opposite end of pin

FIGURE 1

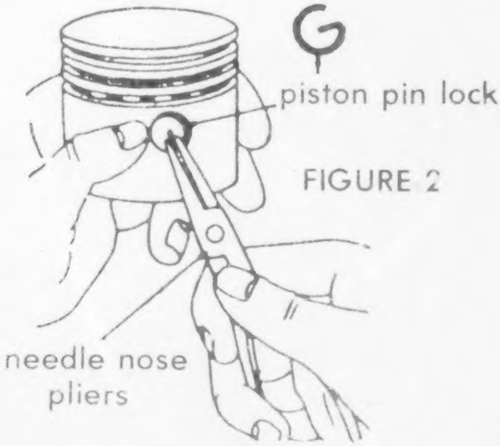

piston pin lock
needle nose pliers

FIGURE 2

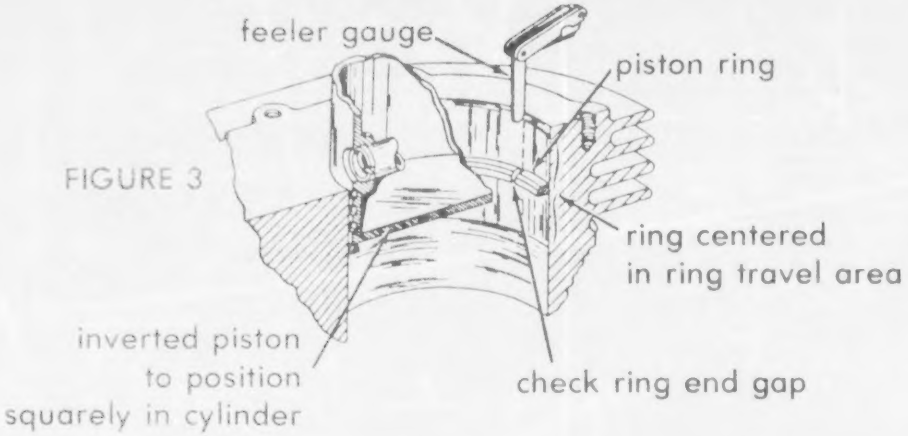
JOB SHEET #7

D. Check ring gap in cylinder

1. Push ring into top of cylinder

2. Align ring in cylinder with piston (Figure 3)

FIGURE 3


feeler gauge
piston ring
ring centered in ring travel area
inverted piston to position squarely in cylinder
check ring end gap

3. Measure gap with feeler gauge

4. Compare to manufacturer's specification

(NOTE: Gap should be correct if cylinder was reconditioned in Job Sheet #2 and the correct rings are being used.)

E. Install rings or piston in correct position, using correct size ring expander (Figures 4 and 5)

FIGURE 4

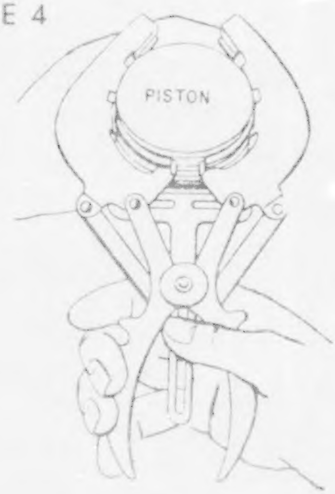
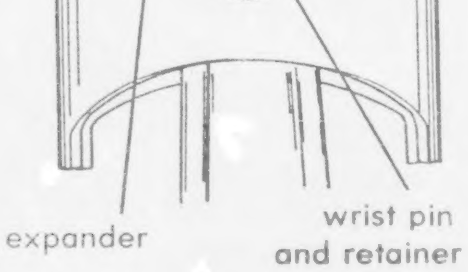


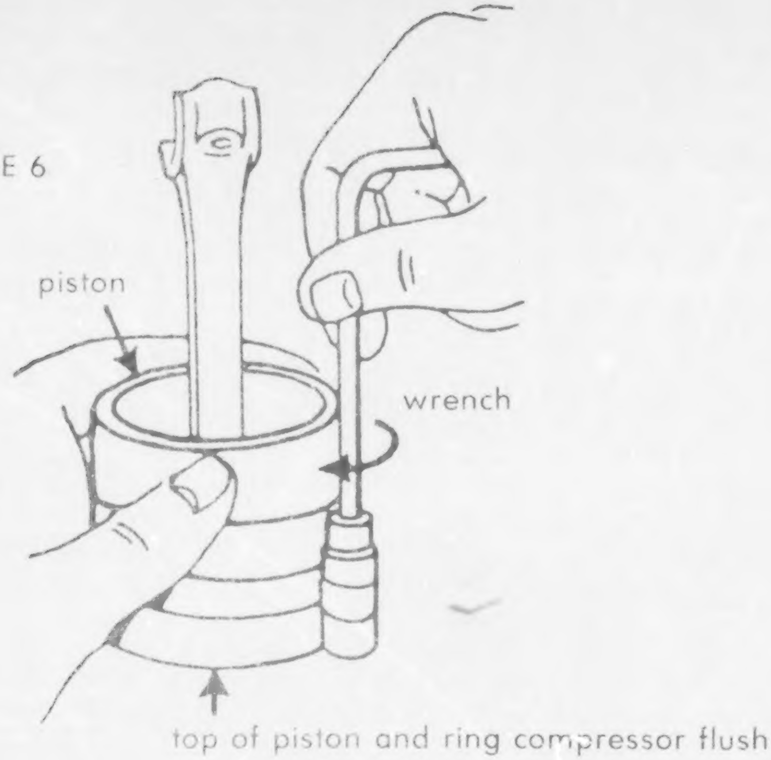
FIGURE 5


ring gaps
expander
wrist pin and retainer

JOB SHEET #7

F. Install ring compressor on piston (Figure 6)

FIGURE 6


piston
wrench
top of piston and ring compressor flush

G. Push piston into cylinder using the handle of a hammer

(Caution: Do not pound piston; broken rings may result.)

H. Line rod up in correct position on crankshaft

(NOTE: A plastigage test is often used during reinstallation of caps as a last check.)

JOB SHEET #7

I. Install rod cap, oil slinger, and lock tabs (Figure 7)

(Caution: These must be in correct position or damage will result; check all alignment marks.)

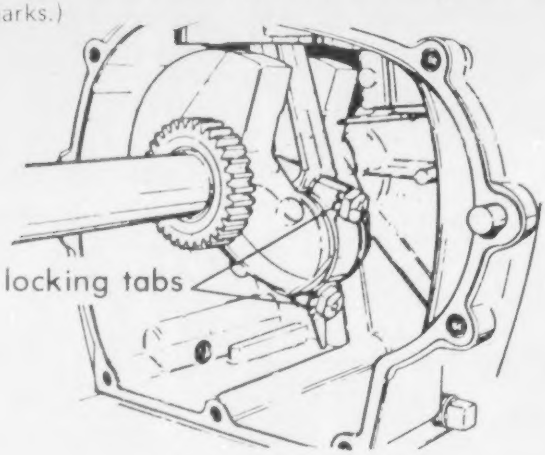


FIGURE 7

bend up locking tabs

J. Torque rod bolts to correct specifications

K. Install tappets

(NOTE: They should be returned to the same location as when removed.)

L. Install camshaft and cam gear (Figure 8)

(NOTE: Align cam gear and crankshaft timing gear marks.)

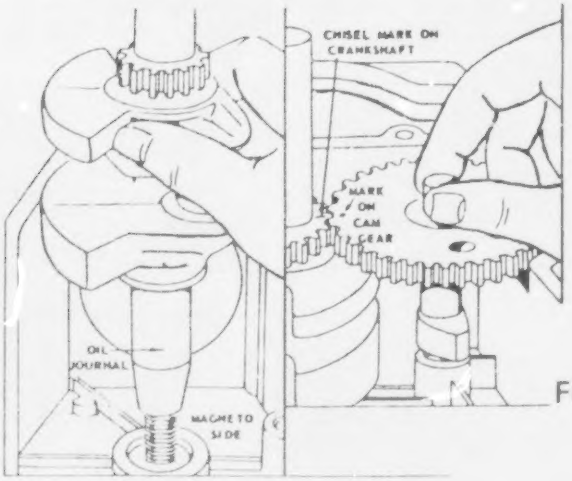

CHISEL MARK ON CRANKSHAFT
MARK ON CAM GEAR
OIL JOURNAL
MAGNETO SIDE

FIGURE 8

JOB SHEET #7

M. Install oil slinger or oil pump if engine is so equipped (Figure 9)

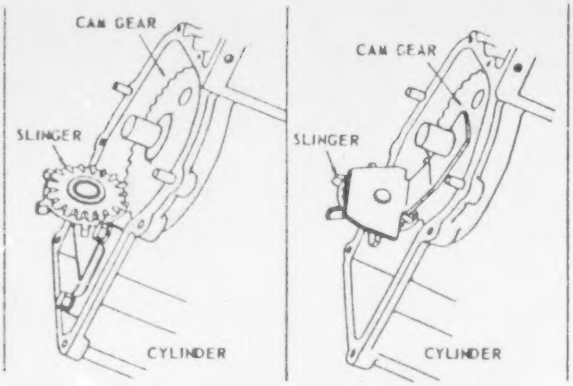

CAM GEAR
SLINGER
CYLINDER
CAM GEAR
SLINGER
CYLINDER

FIGURE 9

(NOTE: Some engines will have a spring washer on the end of the camshaft. Be sure this is in place.)

N. Install gasket on block assembly

(NOTE: Gaskets are different thicknesses to establish correct crankshaft end play on some engines.)

O. Install sump

(Caution: Cover keyway with tape to prevent cutting oil seal.)

P. Torque sump bolts

Q. Check end play of crankshaft (Figure 10)

(NOTE: It might be necessary to change gaskets or install shims to get correct end play. Consult appropriate service manual.)

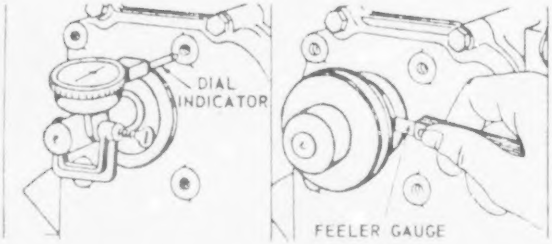

DIAL INDICATOR
FEELER GAUGE

FIGURE 10

R. Install valves in correct position

(NOTE: Do not install springs or keepers.)

JOB SHEET #7

S. Check valves for correct clearance using a feeler gauge (Figure 11)

(NOTE: Grind the end of the valve stem off square for correct tappet to valve stem clearance, if there are no adjusting nuts.)

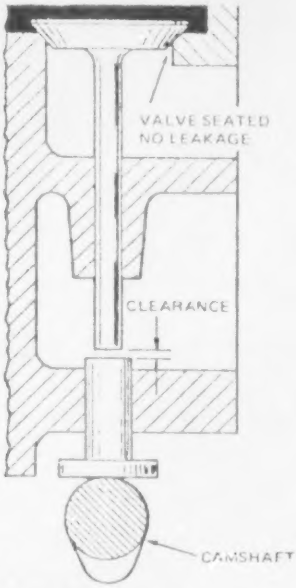


FIGURE 11

T. Install valve springs on correct valves (Figure 12)

(NOTE: Exhaust springs are usually stronger than intake springs. Be sure valve spring washer and keeper are positioned correctly.)

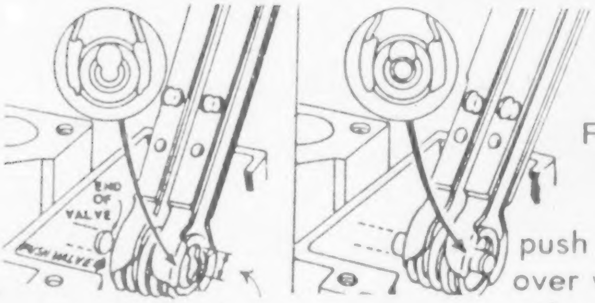


FIGURE 12

large hole in retainer

push spring down over valve stem, release compressor

U. Install valve cover and valve cover gasket

V. Install air deflector shields

W. Install cam plunger, ignition points, and condenser

X. Gap points to correct setting when points are fully open

(NOTE: Coil and ignition switch wires should be correctly attached to condenser post.)

JOB SHEET #7

Y. Install point dust cover

(NOTE: Sealer should be in place where ignition and coil wire enter.)

Z. Install flywheel and flywheel key, washer and starter recoil mechanism

(NOTE: Torque flywheel nut to correct specifications.)

(CAUTION: Be sure to install washer correctly.)

AA. Install coil assembly setting correct air gap to flywheel clearance

(NOTE: Time coil assembly to flywheel if it is adjustable.)

BB. Install air vane governor assembly

(NOTE: This might have to be installed along with coil assembly.)

CC. Check cylinder head for warpage

DD. Install cylinder headgasket, cylinder head, and air deflector

(NOTE: Place bolts in correct position, tighten in correct sequence and to correct torque.)

EE. Install shroud and flywheel cover and fuel tank

FF. Install carburetor gasket, carburetor and governor linkage, and springs

GG. Connect fuel lines and valve cover breather tube

HH. Install muffler and locknut

II. Install engine on equipment or implement

JJ. Connect remote throttle, belts, and other equipment

KK. Fill crankcase with new oil

LL. Install serviced air filter on carburetor

MM. Fill fuel tank with fresh fuel

NN. Install spark plug

JOB SHEET #7

OO. Turn on fuel to carburetor

PP. Make final adjustments

QQ. Have instructor evaluate work

(NOTE: Start engine only after getting instructor's permission.)

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VII

TEST

1. Match the terms on the right to the correct definitions.

______a. To restore to manufacturer's specifications

______b. Wearing or rubbing away

______c. Bearing constructed with balls or rollers between journal and bearing surface to provide rolling instead of sliding friction

______d. Alloy of tin, copper, lead, silver, and antimony having good anti-friction properties; used as a facing for bearings

______e. Clearance or "play" between two parts

______f. Leakage or loss of pressure

______g. Process of wearing into a desirable fit new or reconditioned parts

______h. Removable sleeve used as a bearing

______i. Shaft containing lobes or cams which operate engine valves

______j. Common nonmetallic element which forms in combustion chamber of an engine during burning of fuel and lubricating oil

______k. Space allowed between two parts

______l. Series of weights attached to or forged integrally with the crankshaft, placed so as to offset the reciprocating weight of each piston and rod assembly

______m. Piston pin which is not locked in the connecting rod or the piston, but is free to turn or oscillate in both the connecting rod and the piston

1. Bushing
2. Babbit
3. Camshaft
4. Valve seat
5. Valve grinding
6. Press fit
7. Gasket
8. Valve stem
9. Journal
10. Abrasion
11. Valve lapping
12. Carbon
13. Crankshaft counterbalance
14. Valve clearance
15. Shrink fit
16. Valve margin
17. Running fit
18. Hone
19. Valve face
20. Backlash
21. Valve head
22. Blow-by

______n. Substance placed between two metal surfaces to act as a seal

______o. Abrasive tool for correcting irregularities or differences in diameter in cylinder

______p. Difference in angle between mating surfaces of a valve and a valve seat

______q. Part of a shaft or crank which rotates inside a bearing

______r. Term used to describe an engine which is using an excessive amount of lubricating oil

______s. Rocking of loose fitting piston in a cylinder, making a hollow bell-like sound

______t. Known as a force fit or drive fit

______u. Sufficient clearance has been allowed between the shaft and journal to allow free running without overheating

______v. One surface adhering to another because of heat and pressure

______w. Exceptionally tight fit achieved by heating and/or cooling of parts

______x. Process of mating the valve seat and valve face

______y. Process of refacing the valve and seat to manufacturer's specifications

______z. Angle surface of valve which mates with the seat to seal the chamber

_____aa. Top of the large diametered valve end

_____bb. Space between valve face and head

_____cc. Long portion of valve which reciprocates in valve guide

_____dd. Angle surface in engine block or head which provides mating surface for valve face

_____ee. Distance between valve stem and tappet at lowest tappet position

23. Overhaul

24. Seize

25. Piston slap

26. Oil pumping

27. Interference angle

28. Anti-friction bearing

29. Break in

30. Floating piston pin

31. Clearance

2. List five causes of engine problems.

   a.

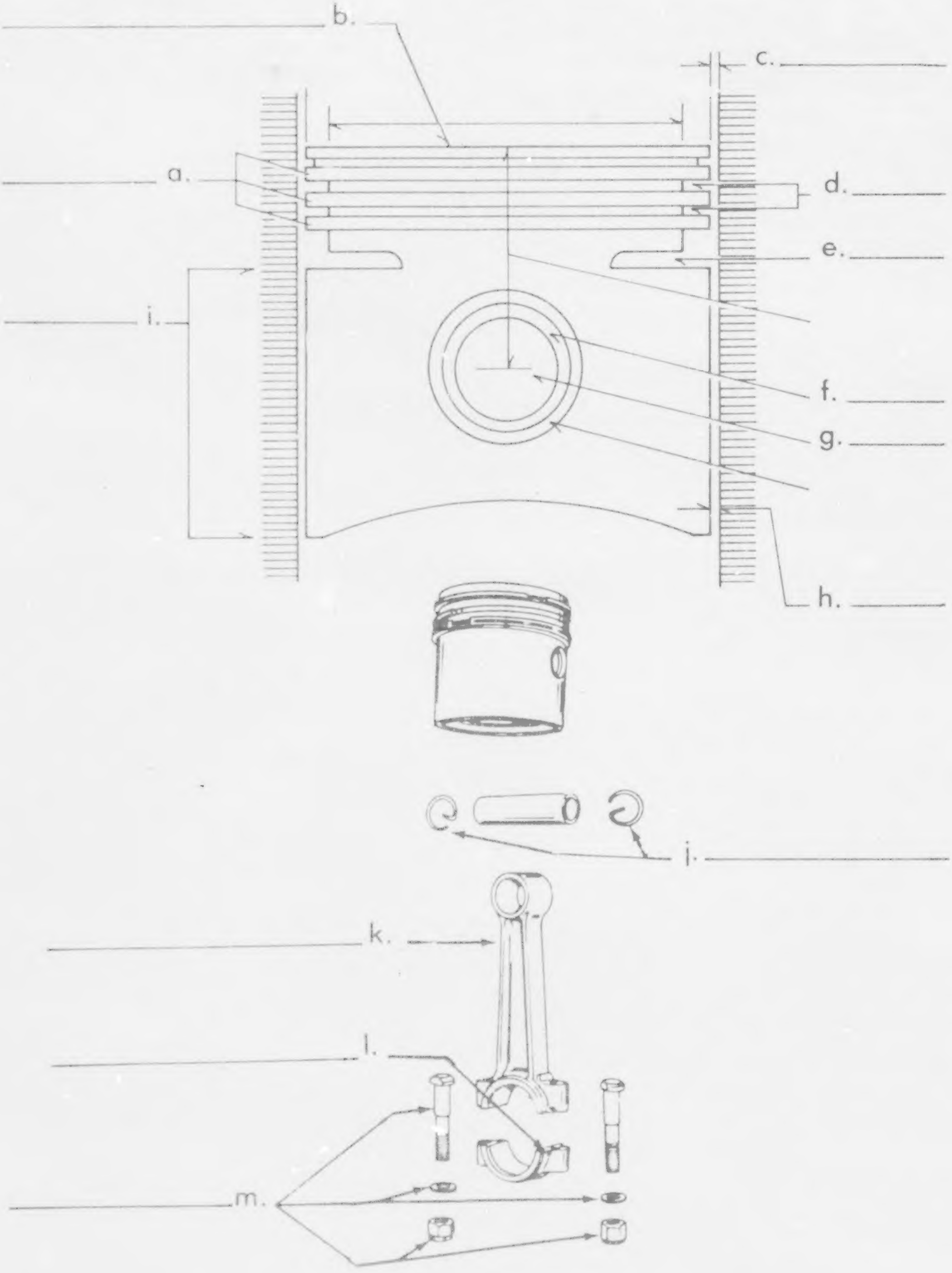
   b.

   c.

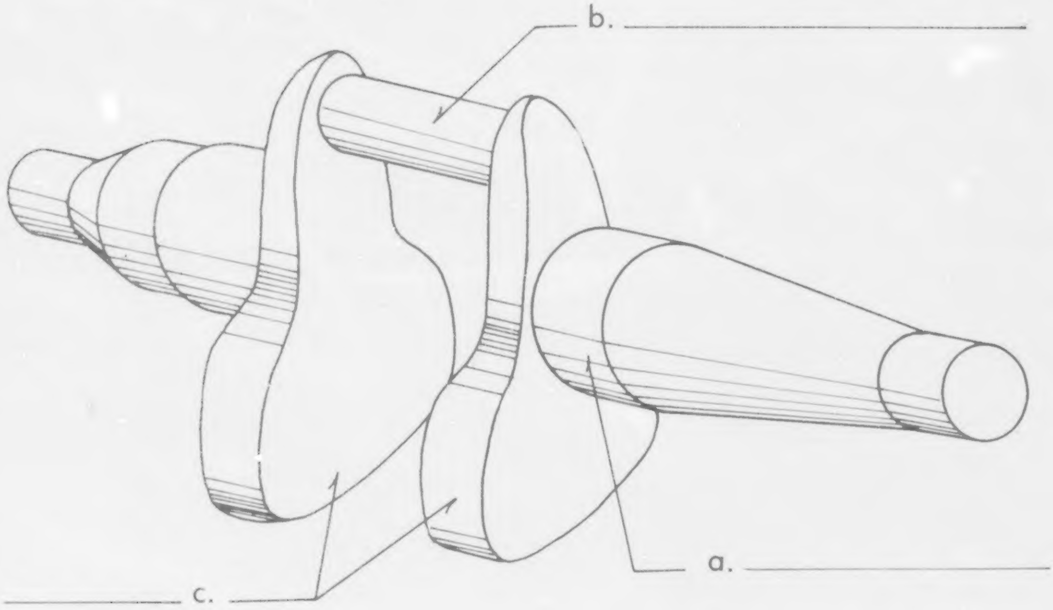
   d.

   e.

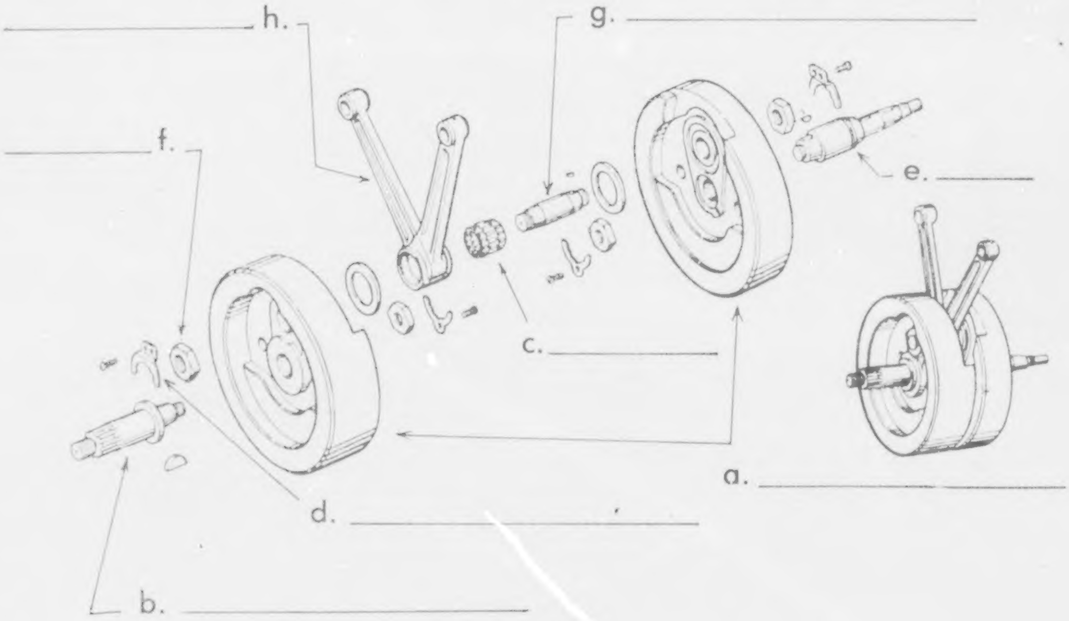
3. Identify the parts of the piston and connecting rod assembly.


b.
c.
a.
d.
e.
i.
f.
g.
h.
j.
k.
l.
m.

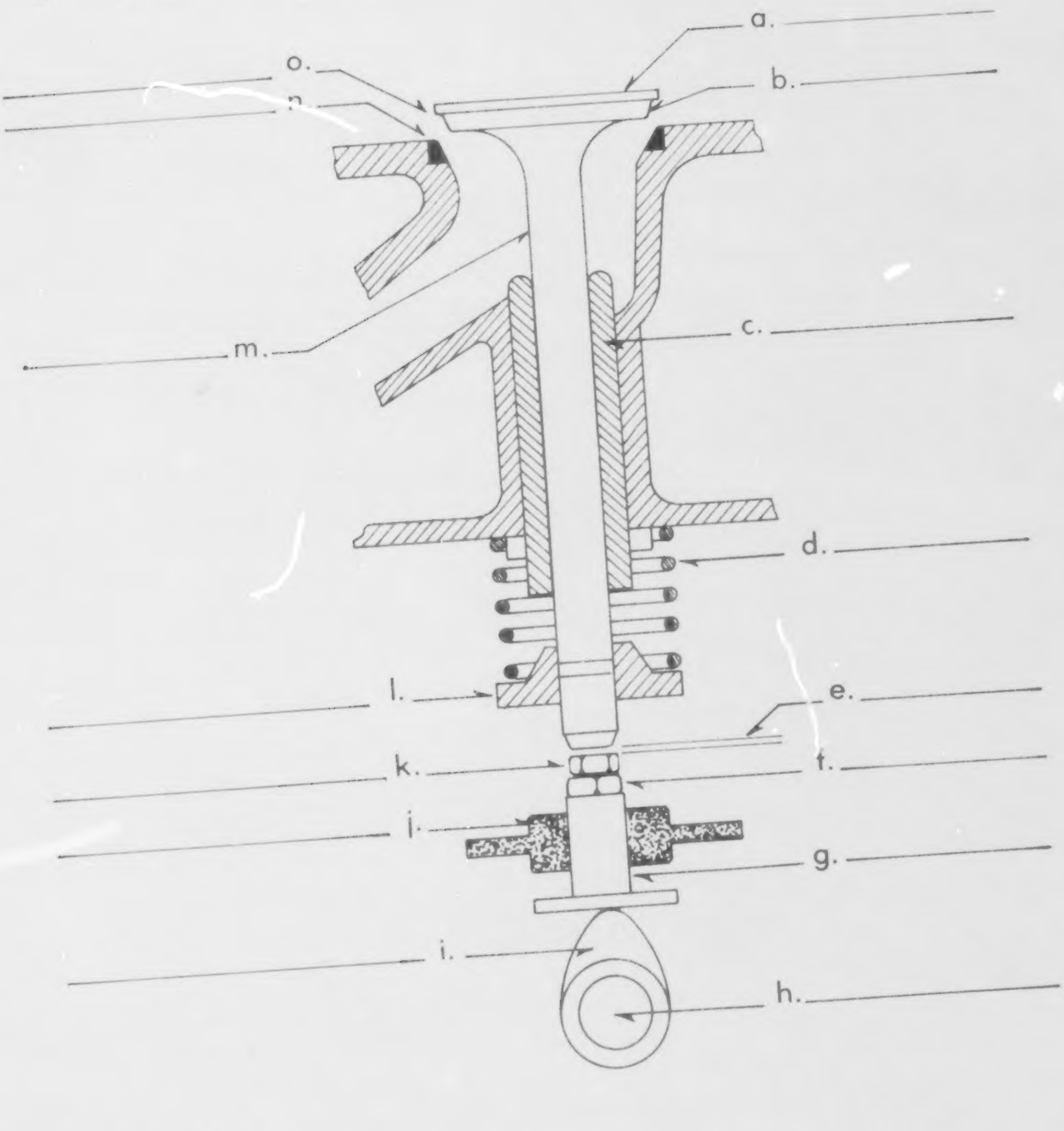
4. Identify the parts of the crankshaft assembly.



5. Identify the parts of the multi-piece crankshaft assembly.



6. Identify the parts of the valve train.



7. Demonstrate the ability to:

a. Disassemble a four-stroke cycle engine.

b. Inspect and service a cylinder.

c. Inspect and service the piston, rings, and connecting rod.

d. Inspect and service a crankshaft assembly.

e. Service a multi-piece crankshaft assembly.

f. Inspect and service a valve assembly.

g. Reassemble a four-stroke cycle engine.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

OVERHAUL FOUR-STROKE CYCLE ENGINE
UNIT VII

ANSWERS TO TEST

1. a. 23

   b. 10

   c. 28

   d. 2

   e. 20

   f. 22

   g. 29

   h. 1

   i. 3

   j. 12

   k. 31

   l. 13

   m. 30

   n. 7

   o. 18

   p. 27

   q. 9

   r. 26

   s. 25

   t. 6

   u. 17

   v. 24

   w. 15

   x. 11

   y. 5

   z. 19

   aa. 21

   bb. 16

   cc. 8

   dd. 4

   ee. 14

2. a. Allowing dirt to get into the engine

   b. Failure to check crankcase oil level often enough and letting engine run low on oil

   c. Overloading the engine so that it works too hard

   d. Running the engine too fast

   e. Failure to properly store the engine during the off season

3. a. Land

   b. Piston head

   c. Ring side clearance

- d. Compression and scraper ring groove
- e. Oil ring groove
- f. Piston pin (wrist pin)
- g. Pin hole
- h. Skirt clearance
- i. Skirt
- j. Retaining ring
- k. Connecting rod
- l. Connecting rod bearing cap
- m. Connecting rod bolts, washers, and nuts

4. a. Main bearing journals
   - b. Crankpin
   - c. Counterweights
5. a. Crank wheels
   - b. Sprocket shaft
   - c. Bearing rollers and retainers
   - d. Lock plate
   - e. Pinion shaft
   - f. Crankpin nuts
   - g. Crankpin
   - h. Connecting rods
6. a. Head
   - b. Face
   - c. Valve guide
   - d. Valve spring

e. Clearance

f. Locknut

g. Tappet

h. Shaft

i. Cam

j. Tappet guide

k. Adjusting nut

l. Retainer

m. Stem

n. Seat

o. Margin

7. Performance skills to be evaluated to the satisfaction of the instructor

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT VIII

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with two-stroke cycle engine overhaul to the definitions. The student should also be able to list causes of engine problems, disassemble, inspect service, and reassemble a two-stroke cycle engine. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the overhaul of two-stroke cycle engines to the correct definitions.
2. List causes of two-stroke cycle engine problems.
3. Identify the parts of the two-stroke cycle piston and connecting rod assembly.
4. Identify the parts of a two-stroke cycle crankshaft assembly.
5. Demonstrate the ability to:
    a. Disassemble, inspect, and service a two-stroke cycle engine.
    b. Service a multi-piece crankshaft.
    c. Reassemble a two-stroke cycle engine.

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT VIII

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Provide live examples of pistons, connecting rod assemblies, and crankshaft assemblies.

   H. Compare overhaul of the two-stroke cycle engine with the overhaul of the four-stroke cycle engine.

   I. Show integral type and multi-piece crankshaft.

   J. Give test.

II. Student

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Take tests.

INSTRUCTIONAL MATERIALS

A. Objective sheet

B. Information sheet

C. Transparency masters

   1. TM 1--Parts of Piston and Connecting Rod Assembly

   2. TM 2--Parts of Crankshaft Assembly

- D. Job sheets
    1. Job Sheet #1--Disassemble, Inspect, and Service a Two-Stroke Cycle Engine
    2. Job Sheet #2--Service a Multi-piece Crankshaft.
    3. Job Sheet #3--Reassemble a Two-Stroke Cycle Engine
- E. Test
- F. Answers to test

II. References

A. *Chilton's Motorcycle Repair Manual.* Radnor, Pennsylvania: Chilton's Motor Co., 1975.

B. *Chilton's Yamaha Repair and Tune-Up Guide.* Radnor, Pennsylvania: Chilton's Motor Co., 1973.

C. *Harley-Davidson Service Manual: Sportster XL/XLH/XLCH, 1970 to 1973.* Harley-Davidson Motor Co., Inc., 1972.

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT VIII

INFORMATION SHEET

I. Terms and definitions

  A. Abrasion--Wearing or rubbing away

  B. Anti-friction bearing--Bearing constructed with balls or rollers between journal and bearing surface to provide rolling instead of sliding friction

  C. Blow-by--Leakage or loss of pressure

  D. Carbon--Common nonmetallic element which forms in combustion chambers of an engine during burning of fuel and oil mixture

  E. Hone--Abrasive tool for correcting irregularities or differences in diameter in a cylinder, such as an engine cylinder

  F. Two cycle oil--Oil specifically formulated to be added to gasoline and used in two-stroke cycle engines

II. Causes of two-stroke cycle engine problems

  A. Incorrect ratio of two cycle oil mixed with fuel

  B. Incorrect type of oil mixed with fuel

  C. Allowing dirt to get into engine

  D. Running the engine too fast

  E. Failure to properly store the engine during the off season

  F. Overheating of engine

  G. Clogging of exhaust

III. Parts of piston and connecting rod assembly (Transparency 1)

  A. Land

  B. Ring groove

  C. Ring groove pin

  D. Connecting rod

INFORMATION SHEET

E. Needle bearings

F. Rod cap

G. Cap screws

H. Match marks

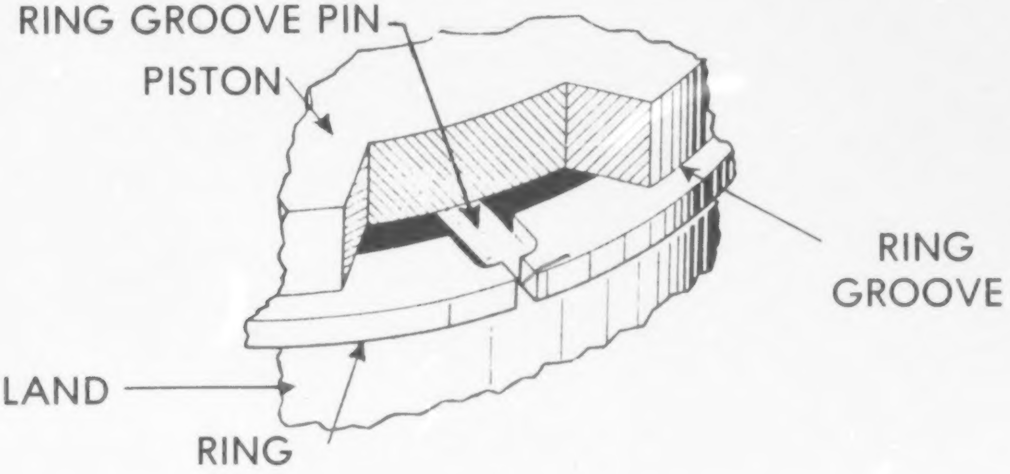
IV. Parts of the two cycle crankshaft assembly (Transparency 2)

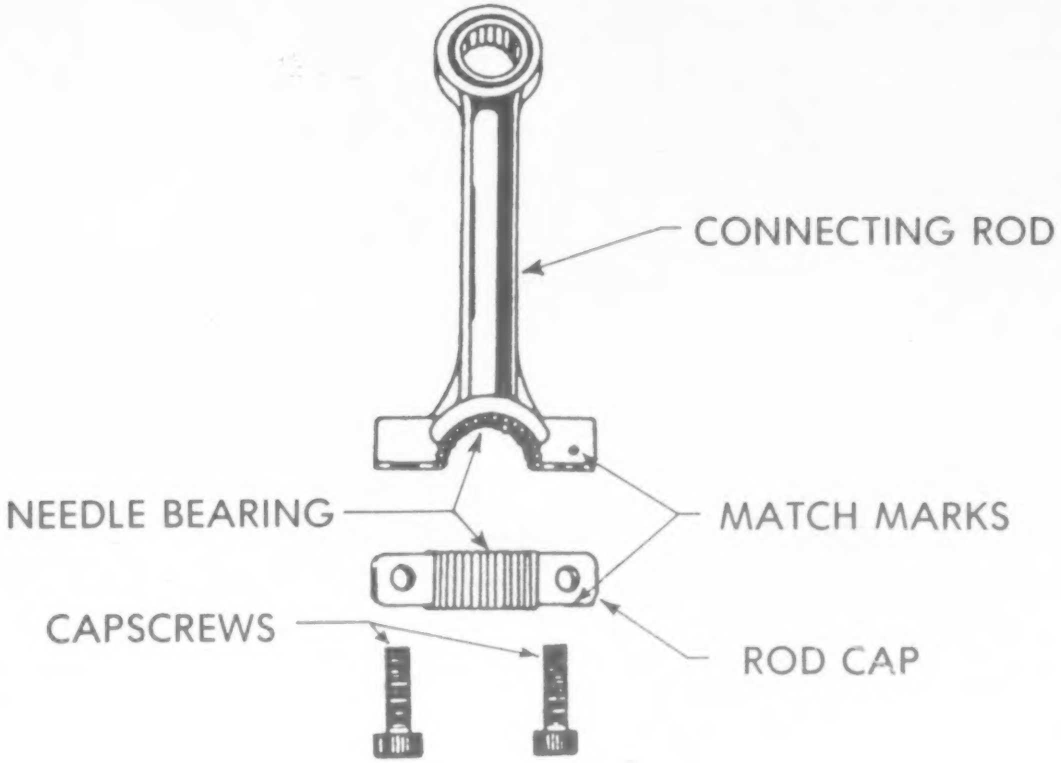
A. Main bearing journals

B. Crankpin (connecting rod bearing journal)

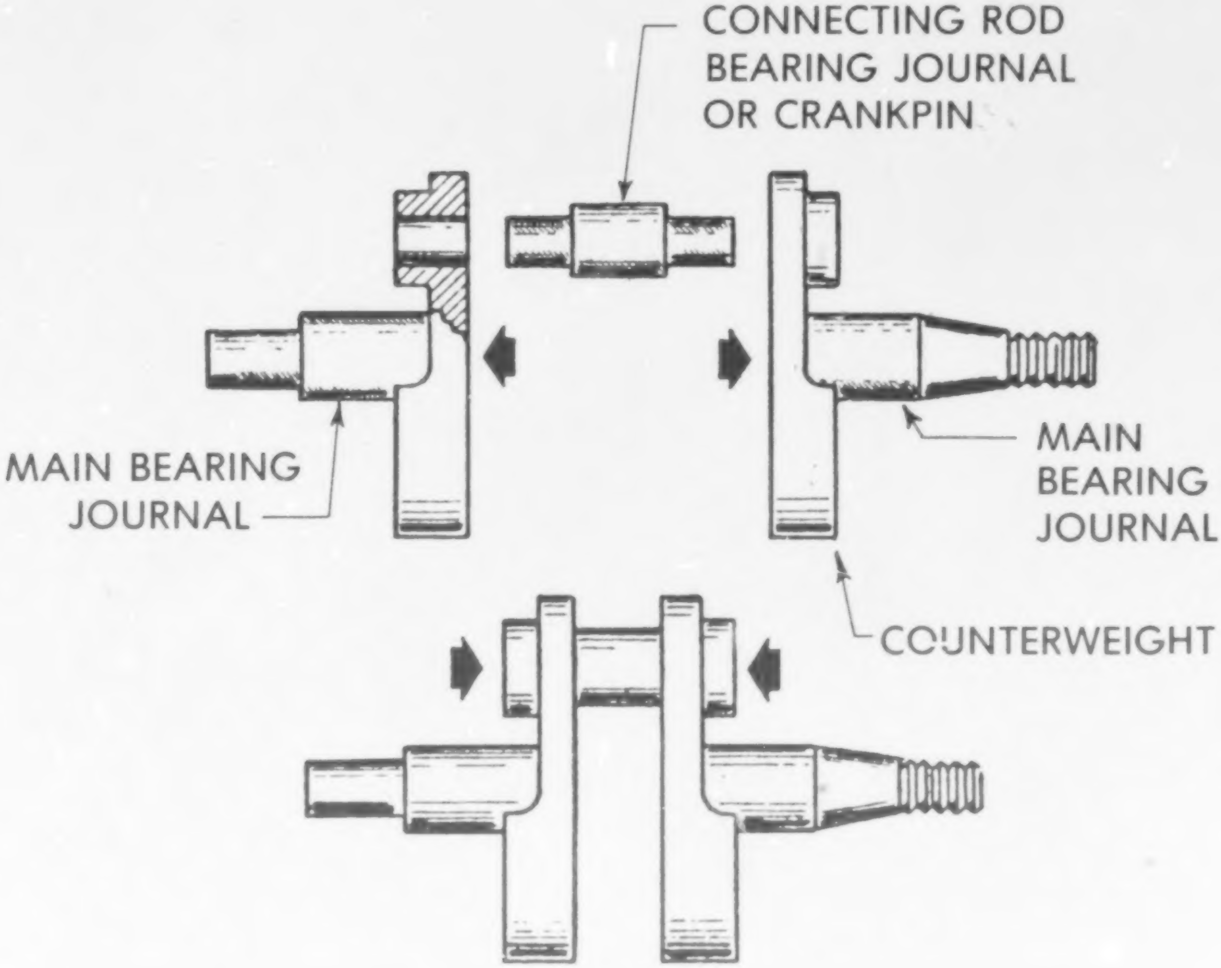
C. Counterweights

PARTS OF PISTON AND CONNECTING ROD ASSEMBLY


RING GROOVE PIN
PISTON
RING GROOVE
LAND
RING


CONNECTING ROD
NEEDLE BEARING
MATCH MARKS
CAPSCREWS
ROD CAP

PARTS OF CRANKSHAFT ASSEMBLY


CONNECTING ROD BEARING JOURNAL OR CRANKPIN
MAIN BEARING JOURNAL
MAIN BEARING JOURNAL
COUNTERWEIGHT

Multi-piece crankshafts have various parts pressed together under heavy pressure.

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT VIII

JOB SHEET #1-DISASSEMBLE, INSPECT, AND SERVICE A TWO-STROKE CYCLE ENGINE

I. Tools and materials

A. Hand tool assortment

B. Piston stop

C. Soft headed hammer

D. Special tools as needed for engine

E. Engine stand

F. Shop towels

G. Cleaning solvent

H. Engine manufacturer's shop manual

I. New oil seals

J. Deglazing tool

K. Safety glasses

II. Procedure

A. Disconnect high tension lead(s)

B. Remove engine shroud or cover

C. Disconnect battery leads to starter

D. Disconnect external fuel lines

E. Disconnect external throttle, shift and clutch control cables attached to engine assembly

F. Remove engine from assembly

(NOTE: On large outboards the lower unit can remain attached to the boat; on smaller outboards it is often easiest to remove the outboard from the boat and remove the engine on a work bench.)

G. Mount engine on suitable stand

(NOTE: Some engines are quite heavy and should be lifted with a winch or with assistance of other mechanics.)

JOB SHEET #1

H. Remove spark plug(s)

I. Remove flywheel

(NOTE: Refer to appropriate service manual for specific pullers and procedures.)

J. Check flywheel for broken cooling fins, damaged gear teeth, magnet strength, and damaged keyways

(NOTE: As a general rule if you place a 1/2" socket on the magnet and can shake the flywheel without it falling off, the magnets have sufficient strength.)

K. Remove air baffles

L. Remove armature plate

M. Remove flywheel key

(NOTE: Roll the key out of the groove.)

N. Remove governor assembly from crankshaft

(NOTE: Sketch the linkage for reassembly.)

O. Remove dust cover

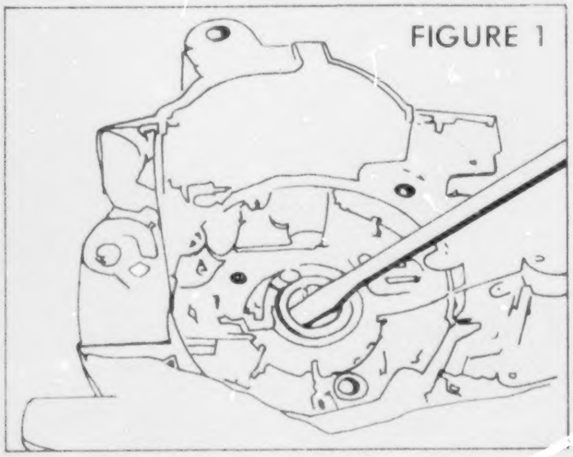
P. Remove spark advance mechanism

Q. Remove magneto plate assembly

(NOTE: On some engines crankshaft main needle bearings must be held in place to prevent them from falling out.)

R. Remove oil seal from armature plate (Figure 1)

FIGURE 1



JOB SHEET #1

S. Remove armature plate bearing (Figures 2 and 3)

(NOTE: It often helps to heat casing before removing bearings.)

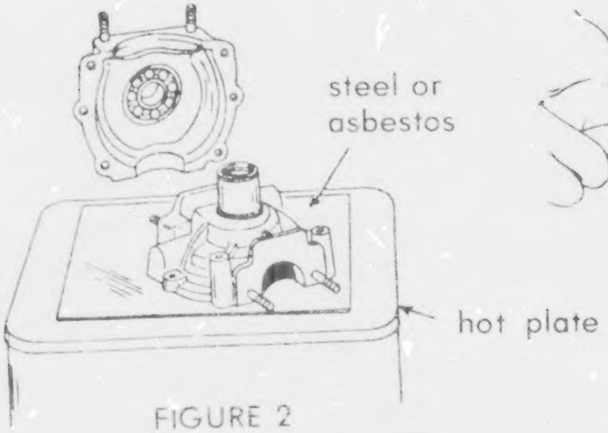

steel or
asbestos
hot plate

FIGURE 2

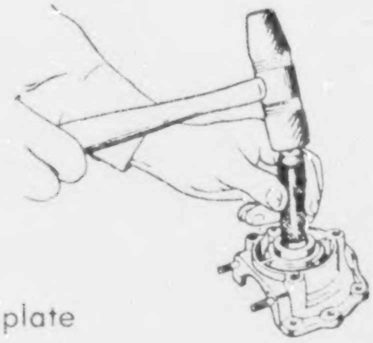


FIGURE 3

T. Install new oil seal (Figure 4)

(NOTE: Refer to appropriate service manual for specific tools and directions.)

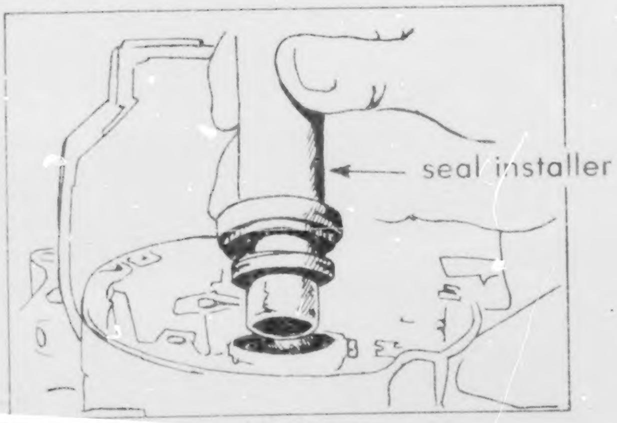

seal installer

FIGURE 4

JOB SHEET #1

U. Replace worn bearings in armature plate (Figure 5)

(NOTE: Refer to appropriate service manual.)

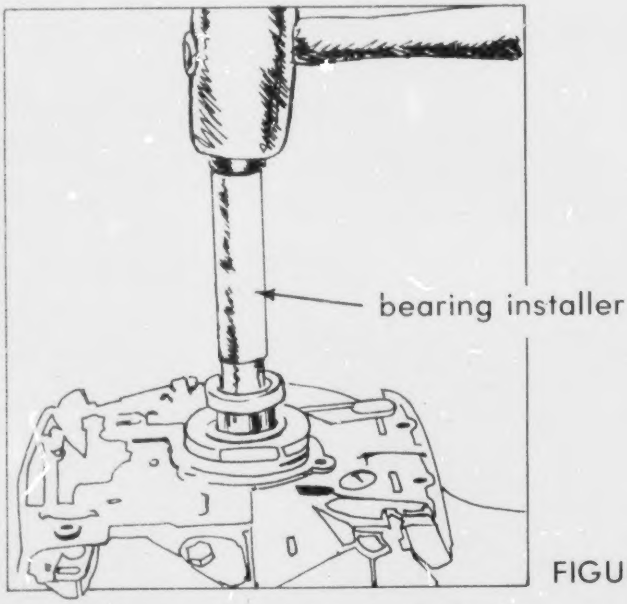


FIGURE 5

V. Remove carburetor and reed plate assembly

W. Remove cylinder or cylinder head

X. Remove rod caps

Y. Remove piston assembly

(NOTE: Use care when removing connecting rods using loose needle bearings. Don't lose them; and be sure they are all in good condition. Replace as necessary.)

(CAUTION: Avoid lifting with magnets.)

Z. Remove wrist pin retaining rings and drive out pin

(NOTE: Count needle bearings and be careful not to lose any of them.)

AA. Remove crankshaft from crankcase oil seal

BB. Remove crankcase oil seal

CC. Remove, inspect, and replace crankcase bearings as needed

DD. Measure crankshaft journals and pin

(NOTE: Compare to manufacturer's specifications; repair or replace as necessary.)

JOB SHEET #1

EE. Measure cylinder at top, center, and bottom (Figure 6)

(NOTE: Compare to manufacturer's specifications; repair or replace as necessary.)

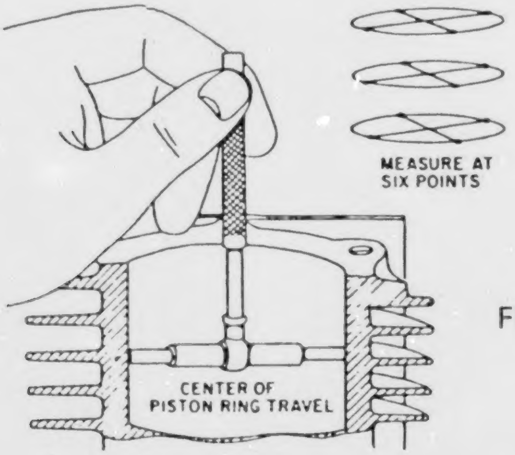

MEASURE AT
SIX POINTS
CENTER OF
PISTON RING TRAVEL

FIGURE 6

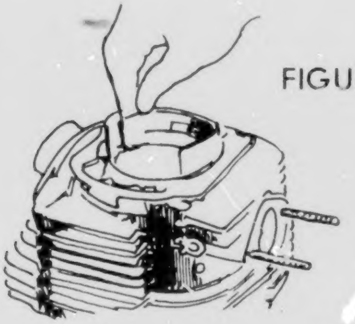
FF. Inspect piston

1. Measure pin bosses
2. Measure skirt
3. Check and scrape pin groove

   (NOTE: Compare these readings to manufacturer's specifications. Replace as required.)

4. Check ring end gap at bottom of ring travel (Figure 7)

FIGURE 7



OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT VIII

JOB SHEET #2-SERVICE A MULTI-PIECE CRANKSHAFT

I. Tools and materials

  A. Hand tool assortment

  B. Dial indicator

  C. Feeler gauge

  D. V-block

  E. Shop manuals

  F. Hydraulic press

  G. Shop towels

  H. Safety glasses

II. Procedure

  A. Disassemble engine to expose crankshaft

  (NOTE: Use appropriate job sheet and service manual.)

  B. Remove crankshaft assembly from engine

JOB SHEET #2

C. Check connecting rod side play (Figure 1)

(NOTE: Value in excess of manufacturer's specifications will necessitate disassembly of the crankshaft.)

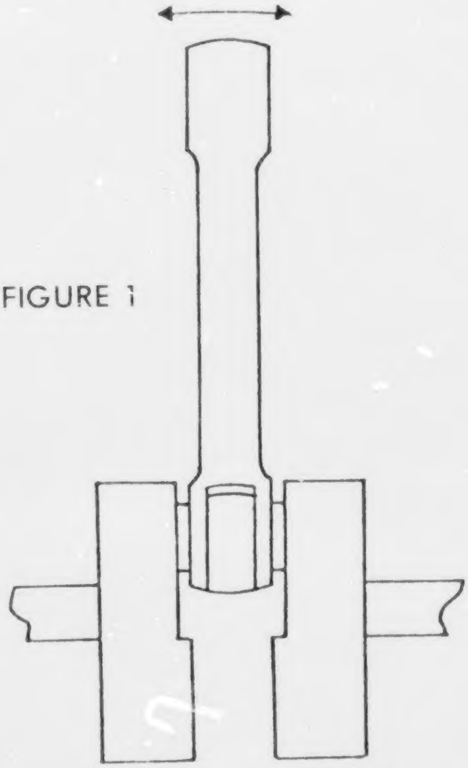


FIGURE 1

D. Disassemble crankshaft assembly

1. Clean crankshaft assembly

2. Place crankshaft in hydraulic press

3. Press apart crankshaft assembly

(NOTE: Some crankshafts have expansion plug in the crankpin end and have to be removed before crankshaft disassembly.)

E. Reassemble the crankshaft halves

1. Press the crankpin into one of the crankshaft halves until the pin is flush with the outer surface of the crankwheel

2. Install one of the thrust washers on the crankpin

JOB SHEET #2

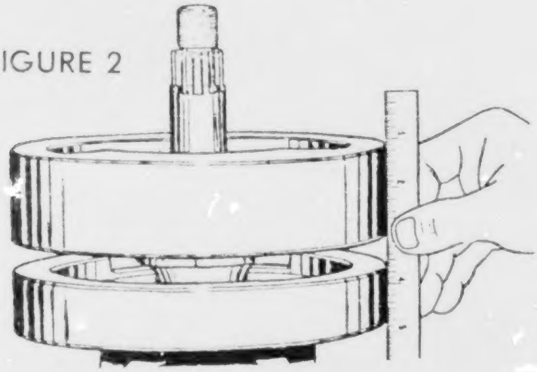
3. Pack the bearing cage with light grease and place a roller in each window of the cage

4. Place the cage bearing on the crankpin

5. Install connecting rod over cage bearing and put the other thrust washer on the crankpin

6. Using a straightedge as a guide, press the other crankshaft half in until the outer surface of the crankwheel is flush with the end of the crankpin (Figure 2)

FIGURE 2



7. Insert the proper feeler gauge between a thrust washer and crankwheel

8. Press the crankshaft assembly together until the feeler gauge is a tight fit

F. Align crankshaft assembly

1. Install crankshaft assembly in a V-block or other suitable centering device (Figure 3)

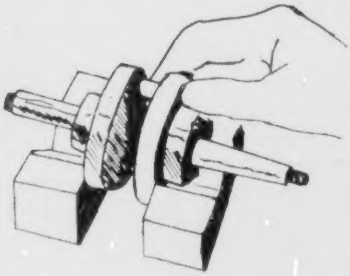


FIGURE 3

JOB SHEET #2

2. Mount dial indicators on bearing journals (Figure 4)

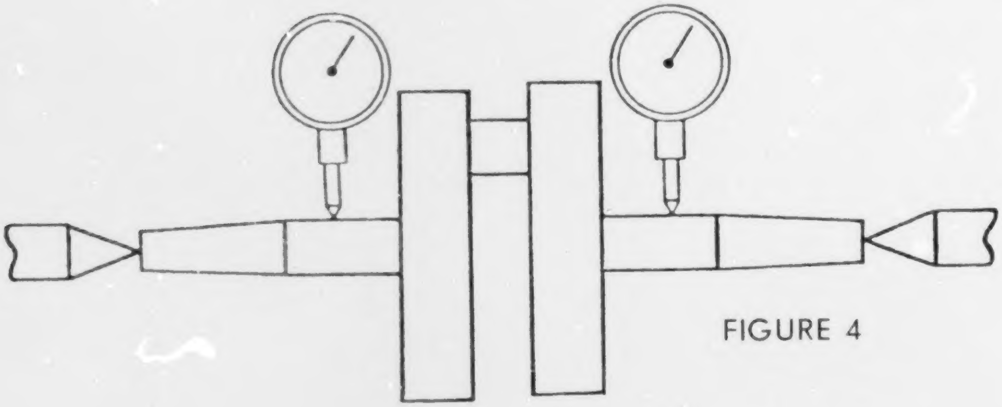


FIGURE 4

3. Rotate crankshaft and note indicator readings

4. Align shaft so maximum needle readings are the same

   a. Rotate the crank until sprocket side dial indicator reads its maximum

   b. Mark crank wheel in line with dial indicator plunger

   c. Remove crank from V-block

   d. Tap crankwheel lightly with soft face hammer at mark (Figure 5)

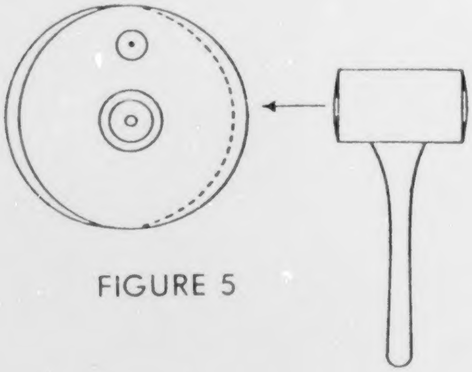


FIGURE 5

   e. Reinstall in V-block and recheck readings

   f. Repeat until readings are the same

JOB SHEET #2

5. Adjust for pinch or spread

(NOTE: After the foregoing adjustment the crank may still be pinched or spread. If the indicators show a maximum travel when crankpin in toward the dial indicator, it is pinched; if maximum is shown when crankpin is away from indicators, the wheels are spread.)

a. Correct pinched wheels

1) Remove assembly from V-block

2) Drive wedge between wheels away from pin (Figure 6)

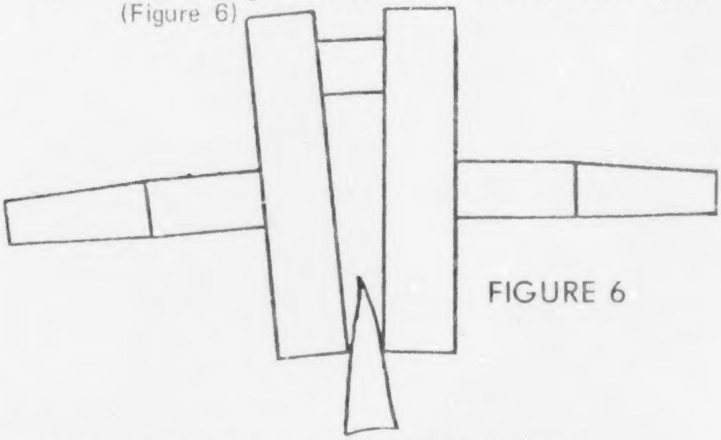


FIGURE 6

3) Replace in V-block and recheck runout

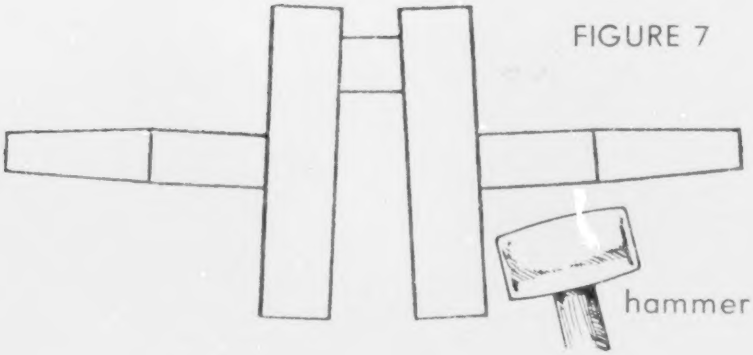
4) Repeat until manufacturer's specifications are met

b. Correct spread wheels

1) Remove crankshaft from V-block

2) Tap wheels opposite crankpin toward each other (Figure 7)

FIGURE 7



JOB SHEET #2

        3) Replace in V-block and check runout

        4) Repeat until manufacturer's specifications are met

    6. Replace expansion plugs if used

G. Have instructor evaluate work

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT VIII

JOB SHEET #3 REASSEMBLE TWO-STROKE CYCLE ENGINE

I. Tools and materials

- A. Hand tool assortment
- B. Piston stop
- C. Special tool for engine reassembly
- D. Piston ring compressor
- E. Light oil, 5-10 weight
- F. New gasket set
- G. Shop towels
- H. Engine stand
- I. Safety glasses

II. Procedure

A. Install crankshaft in crankcase

(NOTE: All metal to metal surfaces should be coated with 2 cycle oil.)

(CAUTION: Do not damage oil seal when installing crankshaft.)

B. Drive wrist pin through piston and connecting rod

(NOTE: Install connecting rod on piston so as not to damage needle bearing.)

C. Install wrist pin retainer rings

(NOTE: They must be installed correctly or they will pop out during operation.)

D. Place strip of needle bearings on crankshaft (Figure 1)

(NOTE: If old needles are to be reinstalled coat them in petroleum jelly or a suitable lubricant so they will adhere to rod and cap.)

JOB SHEET #3

(CAUTION: Correct number of needle bearings must be installed on rod and cap; check this carefully.)

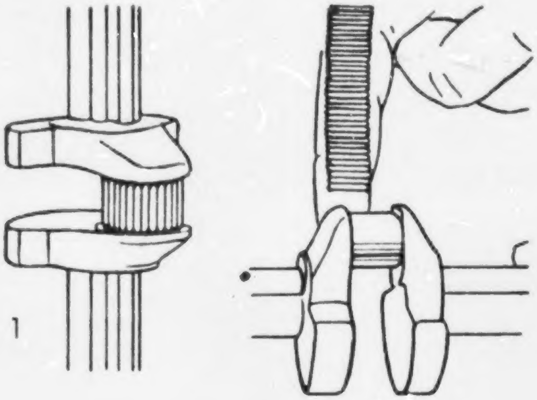


FIGURE 1

E. Install rod on crankshaft journal and install rod cap

(NOTE: Tighten rod cap bolts finger tight, ie., just enough to hold needle bearings in place.)

(CAUTION: Piston will have a mark to identify the top location; this must be installed up.)

F. Install cylinder to crankcase gasket in correct location

G. Install ring compressor over head of piston and compressor rings

(NOTE: Rings should be coated with light oil. See Figure 2.)

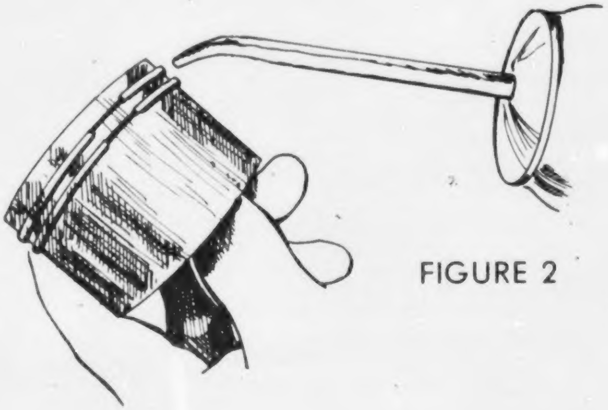


FIGURE 2

JOB SHEET #3

H. Maintain pressure on rings and slide rings into cylinder (Figure 3)

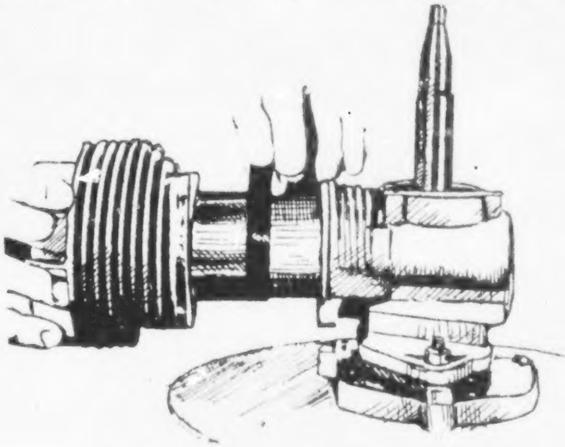


FIGURE 3

I. Center rod on wrist pin

J. Torque rod capscrews to correct torque (Figure 4)

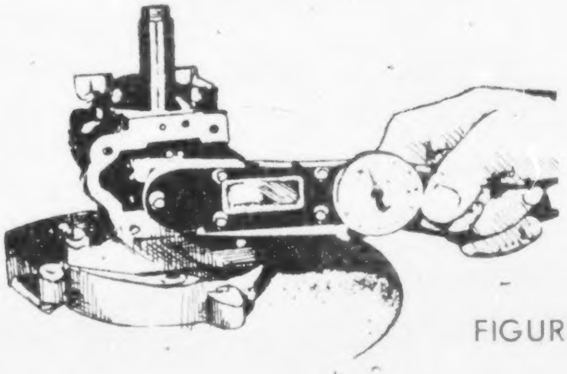


FIGURE 4

JOB SHEET #3

K. Bend lock tabs to retain rod capscrews (Figure 5)

(NOTE: Use new tabs as necessary.)

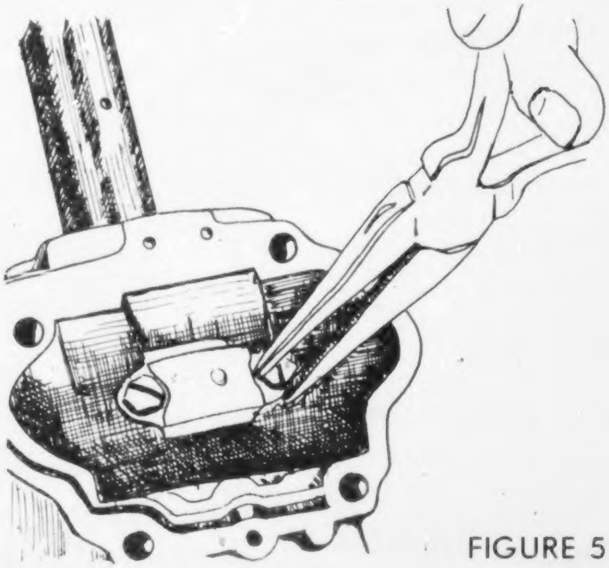


FIGURE 5

L. Torque cylinder to crankcase bolts

(NOTE: Check to be sure washers are located in correct position as some bolts do not have washers.)

M. Install reed plate and carburetor on engine

(NOTE: Locate gasket correctly on crankcase.)

N. Install armature plate on crankcase using correct gasket to have correct crankshaft end play

(NOTE: Properly protect seal and main bearings when installing armature plate.)

O. Tighten armature to crankcase screws

P. Check ignition point gap

Q. Install flyweight on crankshaft

(NOTE: Install in correct location with crankshaft keyway.)

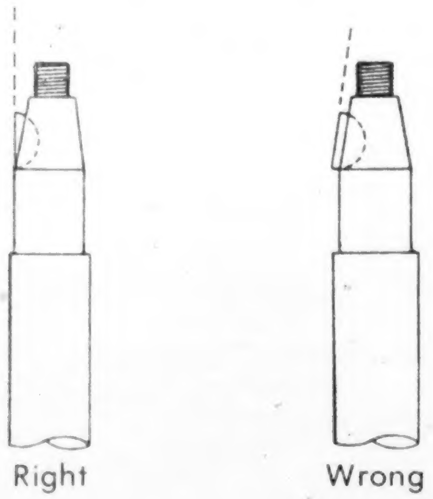
JOB SHEET #3

R. Install dust cover

S. Install governor assembly

T. Install flywheel and torque flywheel nut to correct torque

(NOTE: Flywheel key must be installed correctly. See Figure 6.)



make sure key is installed correctly
FIGURE 6

U. Install air baffles, governor linkage, starter connections, and shroud, and make fuel connections

V. Install spark plug

W. Install spark plug high tension wire

X. Place correct fuel and two cycle oil mixture in fuel tank

Y. Mount engine to implement

Z. Make final adjustments

AA. Check with instructor and start engine

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT VIII

NAME ____________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Oil specifically formulated to be added to gasoline and used in two-stroke cycle engines

_____b. Wearing or rubbing away

_____c. Abrasive tool for correcting irregularities or differences in diameter in a cylinder, such as an engine cylinder

_____d. Bearing constructed with balls or rollers between journal and bearing surface to provide rolling instead of sliding friction

_____e. Leakage or loss of pressure

_____f. Common nonmetallic element which forms in combustion chambers of an engine during burning of fuel and oil mixture

1. Blow-by
2. Hone
3. Two cycle oil
4. Abrasion
5. Anti-friction bearing
6. Carbon

2. List five causes of two-stroke cycle engine problems.

a.

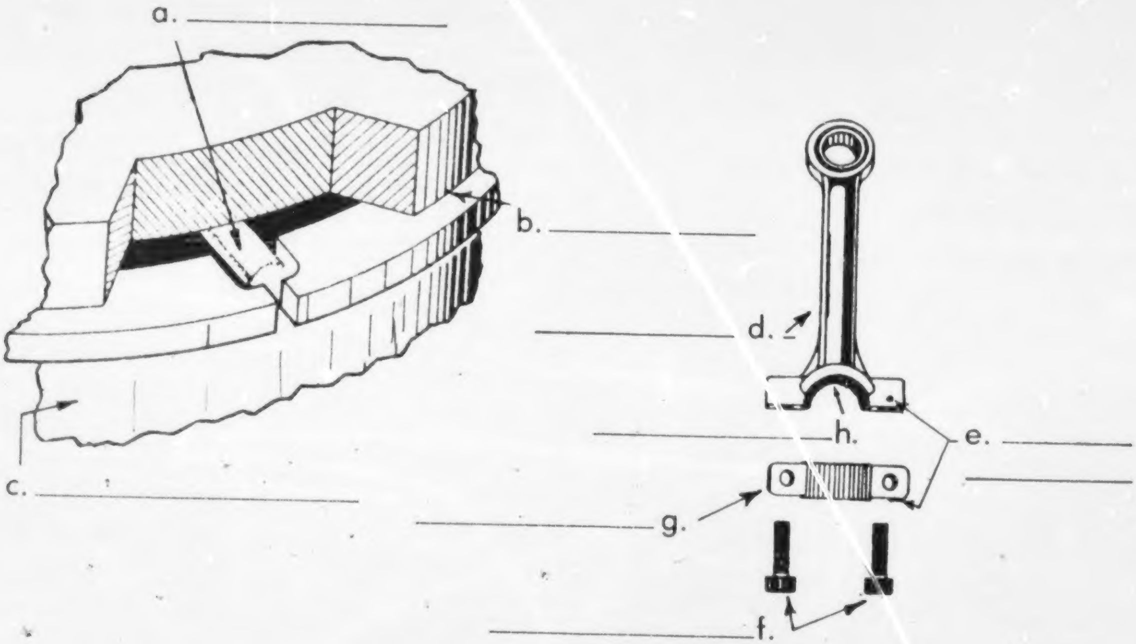
b.

c.

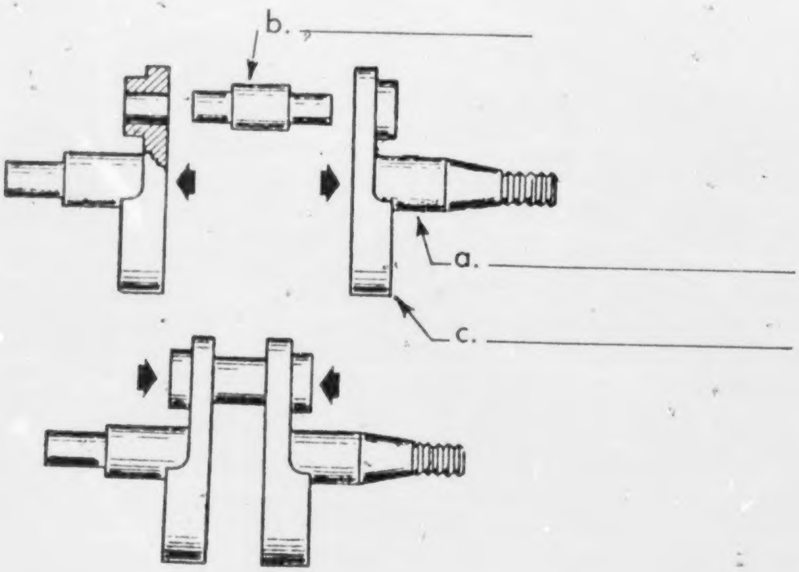
d.

e.

3. Identify the parts of the two-stroke cycle piston and connecting rod assembly.



4. Identify the parts of a two-stroke cycle crankshaft assembly.



5. Demonstrate the ability to:

   a. Disassemble, inspect, and service a two-stroke cycle engine.

   b. Service a multi-piece crankshaft.

   c. Reassemble a two-stroke cycle engine.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

OVERHAUL TWO-STROKE CYCLE ENGINE
UNIT VIII

ANSWERS TO TEST

1. a. 3
   b. 4
   c. 2
   d. 5
   e. 1
   f. 6

2. Any five of the following:
   a. Incorrect ratio of two cycle oil mixed with fuel
   b. Incorrect type of oil mixed with fuel
   c. Allowing dirt to get into engine
   d. Running the engine too fast
   e. Failure to properly store the engine during the off season
   f. Overheating of engine
   g. Clogging of exhaust

3. a. Ring groove pin
   b. Ring groove
   c. Land
   d. Connecting rod
   e. Match marks
   f. Cap screws
   g. Rod cap
   h. Needle bearings

4. a. Main bearing journals
   b. Crankpin (connecting rod bearing journal)
   c. Counterweights

5. Performance skills evaluated to the satisfaction of the instructor